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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 7, Number 1 January 1966

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service ● Division of Radiological Health

THE APPEARANCE OF IODINE-131 AND BARIUM-LANTHANUM-140 IN FALLOUT DUE TO THE SECOND CHINESE NUCLEAR TEST

James E. Johnson, Daniel W. Wilson, and Gerald M. Ward [1]

SYNOPSIS—Fresh fission product debris of the May 14, 1965 Chinese nuclear device test was detected at Fort Collins on May 25. Levels of iodine-131 in milk reached a peak of 130 pCi/liter on June 5. Barium-lanthanum-140 was not detected in milk samples. The expected spring increase of cesium-137 was observed in forage and milk samples.

Evidence of the second mainland Chinese nuclear test of May 14, 1965, was detected at Fort Collins, Colorado, on May 25, 1965. On this date the short-lived fission products ^{141}Ce, ^{103}Ru, ^{95}Zr-Nb, and ^{140}Ba-La were found in precipitation and on forage samples which were being collected routinely in a study of fallout deposition at Colorado State University. These nuclides were first identified in a gamma-ray spectrum of an alfalfa sample harvested on May 25 and counted one week later (*1*). The radionuclides ^{125}Sb, ^{137}Cs, and ^{54}Mn from older nuclear debris were completely masked in the gamma-ray spectrum by the photopeaks of the shorter-lived nuclides in the fresh fallout. The normal spring increase in ^{144}Ce, ^{125}Sb, ^{106}Ru, ^{137}Cs, and ^{54}Mn was expected at approximately that time as it had been observed here for the previous three years of fallout monitoring. By means of chemical separations of fission products in forage (*2*), an increase in cesium-137 content was shown from May 20 to June 4. The increase in cesium-137 was probably almost all due to the normal spring injection of older debris and not to the Chinese test.

Iodine-131 was detected on May 27 in the milk from a nine-cow herd fed greencut alfalfa harvested daily. Iodine-131 levels in milk from May 25 to June 26 are given in figure 1. Pasture forage levels of barium-lanthanum-140 are shown in the same figure. By comparison, the iodine-131 concentrations in milk from our pasture herd during July 1962 reached a peak around 4,000 pCi/liter.

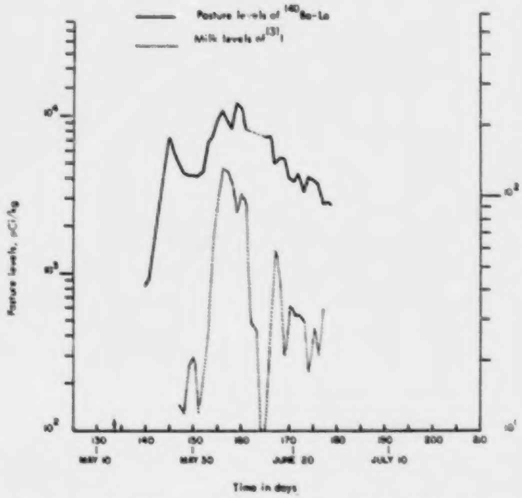

Figure 1. Pasture levels of barium-lanthanum-140 and milk levels of iodine-131 at Fort Collins, Colorado, from the second Chinese nuclear device test (arrow indicates date of detonation)

All environmental samples were counted by gamma-ray spectrometry with an 8- by 4-inch sodium iodide (thallium) crystal under conditions of low background. Barium-lanthanum-140 was not detected in 5.5-liter milk samples counted 2 hours on the large crystal. It was, however, observed in an *in-vivo* gamma-ray spectrum of a cow from the herd. The count was made by a 9- by 4-inch sodium iodide crystal over the rump of the cow in our whole-body counter. Figure 2 shows the gamma-ray spectra of the cow and of the feces sample containing fresh Chinese test debris.

Krey and Rosa (*3*) indicate that the leading edge of the debris cloud from the second Chinese test should have arrived over Fort

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[1] Dr. Johnson is a radiation biologist, Mr. Wilson a chemist, and Dr. Ward, Professor of Animal Science, Colorado State University, Fort Collins, Colorado.

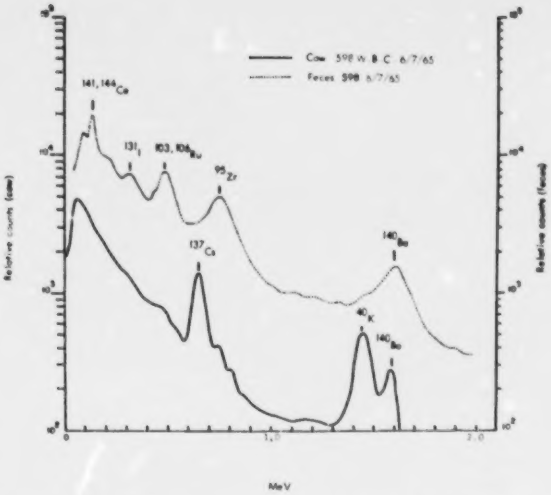

Figure 2. Gamma-ray spectrum of a cow fed green-cut alfalfa and spectrum of feces sample from cow (whole body counting time, 25 minutes; feces counting time, 180 minutes)

Collins about May 18; however, our ground level air sampling did not indicate fresh fallout until 10 days later—May 28. The fresh fallout was detected in rain that fell May 23–25, which indicates that the upper tropospheric activity was being excluded from ground-level air. Between May 23 and June 30, Fort Collins received 6.0 inches of rain, more than one-half the average annual precipitation. This was a major factor in the high total deposition; but due to the frequency of heavy rains, the efficiency of deposition (*i.e.*, the deposition coefficient) is not expected to be high (*4*).

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GAMMA ACTIVITY IN SURFACE AIR—80TH MERIDIAN NETWORK JANUARY-MARCH 1965

Philip W. Krey[1]

SYNOPSIS—Monthly measurements of gamma activity during the first quarter of 1965 are presented for stations in both hemispheres. Latitude profiles of the results for the first 3 months of 1965 show maxima at midlatitudes for both hemispheres, a low near the equator, and a minimum at Chacaltaya, Boliva. Comparison of first-quarter profiles for 1964 and 1965 indicates generally similar shapes, although gamma activity decreased sharply in the Northern Hemisphere in early 1965. Average concentrations for the hemispheres show spring maxima and evidence of the mainland Chinese nuclear test of October 16, 1964, as well as different trends in the two hemispheres.

Gamma activity in surface air has been reported monthly by the U.S. Atomic Energy Commission Health and Safety Laboratory (HASL) since January 1963 as part of a continuation of the 80th Meridian Program initiated by the U.S. Naval Research Laboratory.

The core of the sampling network (figure 1) is a line of 14 stations in the longitude band from 66° W to 80° W, which extends from Thule, Greenland (76° 36′N), to Punta Arenas, Chile (53° 08′S). The U.S. Weather Bureau maintains a site at the Amundsen-Scott South Pole Station, and the samples from this location are also included in the HASL program. The high-altitude station at Mauna Loa, Hawaii (19° 28′N, 155° 36′W), was installed to serve as a comparator and Northern Hemisphere counterpart of the high-altitude station at Chacaltaya, Bolivia (16° 21′S, 68° 07′W), in the Southern Hemisphere.

Figure 1 shows that the stations in the Northern Hemisphere generally lie along the east coast of the continent, while in the Southern Hemisphere, the stations line the west coast. Since the prevailing wind is from west to east, there was concern that there might be some coastal effect. To explore this possibility, six additional sites within the continental United States were activated in August 1963. A review of the data generated by this program and a comparison with the United Kingdom Surface Air Sampling Program have shown that local meteorologic conditions may have some short-term seasonal effects on surface air radioactivity concentrations, but that the annual concentration in a particular latitude band is essentially independent of longitude or coastal effects (*1, 2*).

Sampling and analytical procedures

About 1,400 cubic meters of surface air per day are drawn through an 8-inch (20.32 cm) diameter polystyrene base filter (Microsorban). The filters are changed on the 1st, 8th, 15th, and 22nd of each month. During periods of nuclear testing, the spectrum of each sample is measured at HASL with an 8- x 4-inch NaI (thallium) crystal, approximately 2 weeks after collection. During quiescent periods when fresh fission product debris is absent in surface air, the weekly samples are compressed and assayed as a monthly composite. The gamma ray activity in the range between 100 keV and 3.0 MeV is integrated and reported as the total gamma activity. Subsequently, the weekly samples are combined into a monthly composite and analyzed radiochemically for fission products, induced radionuclides, and specific tracers.

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[1] Mr. Krey is a staff member of the Environmental Studies Division, Health and Safety Laboratory, U.S. Atomic Energy Commission, New York, N.Y. 10014.

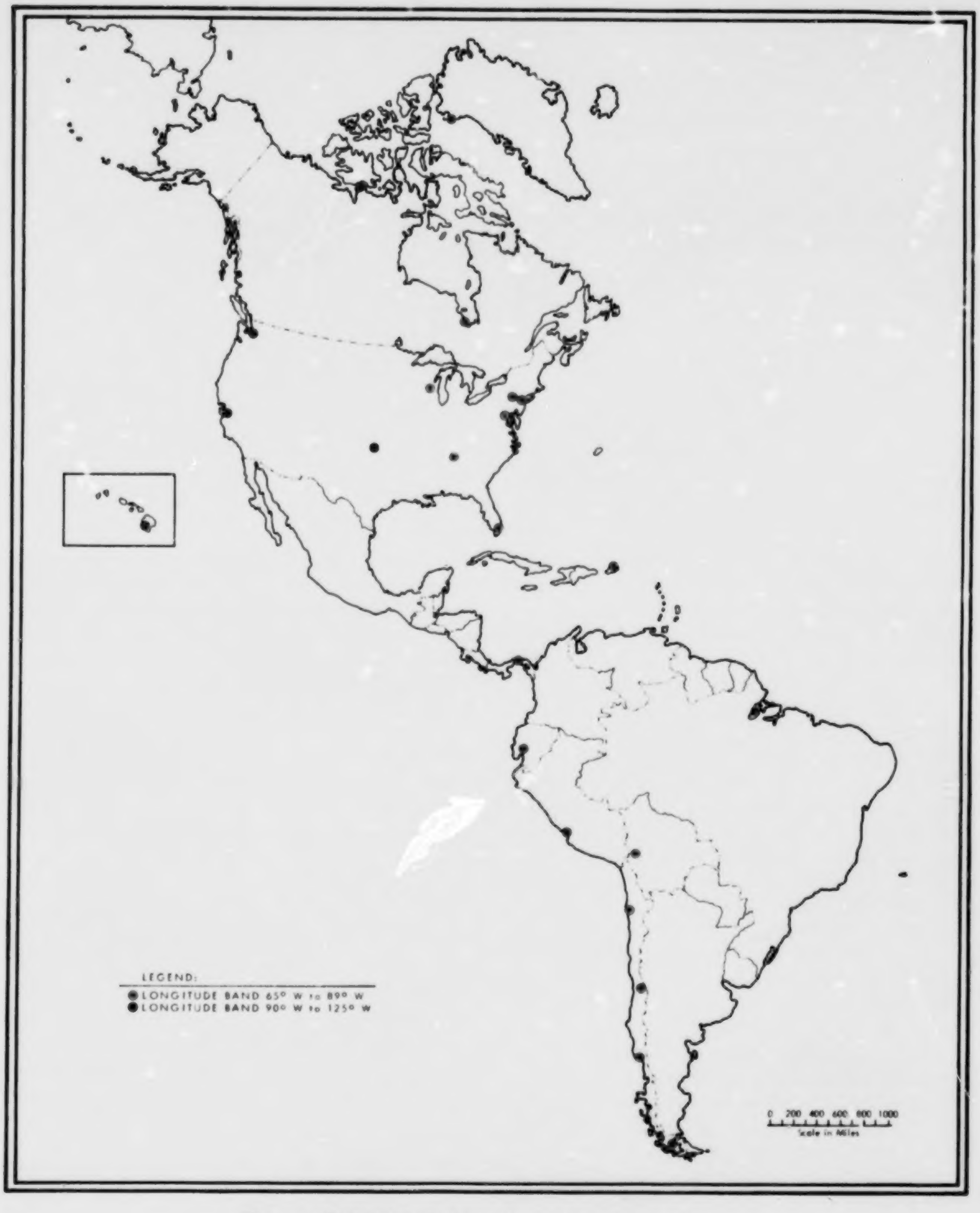
LEGEND:
● LONGITUDE BAND 65° W to 89° W
● LONGITUDE BAND 90° W to 125° W
0 200 400 600 800 1000
Scale in Miles

Figure 1. HASL 80th Meridian Network sampling stations

7

Activity latitude profiles

The total gamma activity concentrations in monthly composited air filter samples for January, February, and March 1965 are given in table 1. The data are corrected to the midpoint of the sampling month via the measured decay curve of several samples collected in both the Northern and Southern Hemispheres. The activity latitude profiles for each month (plot of activity concentration versus latitude) are presented in figures 2, 3, and 4. The averages of the New York and Westwood stations are plotted as a single value on each of the figures. The curves are drawn through the points in the 65° W to 89° W longitude band. The points in the 90° W to 125° W longitude band sometimes deviate from the curves, but they do not significantly alter the profiles.[2] The profile for the average gamma concentrations during the first 3 months of 1965 is compared in figure 5 to the average profile for the first quarter of 1964.

Daily air filter samples were collected at New York from January 21 through February 1 in an effort to detect debris from the U.S.S.R. underground test on January 15. Fresh fission product debris as evidenced by the presence of barium–140 was not discernible in the spectra of any daily or weekly samples. It was concluded that no significant amounts of material from the U.S.S.R. test reached the HASL Surface Air Sampling Network. A similar conclusion was made for the Kiwi destruct test of January 12 (*3*).

Table 1. Gamma activity in surface air January–March 1965

Sampling site	Latitude	Gamma activity (Photons/min•m³)		
		January 1965	February 1965	March 1965
Northern Hemisphere:				
Thule, Greenland	76°36′	0.184	0.132	0.287
Moosonee, Canada	51°15′	0.0983	0.132	0.183
Seattle, Wash	47°36′	0.0684	0.147	0.342
Appleton, Wis	44°15′	0.133	0.188	0.295
Westwood, N. J	41°00′	0.143	0.202	0.202
New York, N. Y	40°48′	0.163	0.223	0.227
Washington, D. C	38°58′	0.140	0.209	0.177
Palo Alto, Calif	37°30′	0.0954	0.227	0.311
Midwest City, Okla	35°25′	0.155	0.195	0.245
Chattanooga, Tenn	35°03′	0.163	0.198	0.204
Miami, Fla	25°49′	0.165	0.198	0.224
Mauna Loa, Hawaii	19°28′	0.128	0.310	0.209
San Juan, P. R	18°26′	0.111	0.133	0.186
Miraflores, C. Z	9°00′	0.0748	0.0844	0.0290
Southern Hemisphere:				
Guayaquil, Ecuador	2°10′	0.0301	0.0236	0.0160
Lima, Peru	12°06′	0.0650	0.0523	0.102
Chacaltaya, Bolivia	16°21′	0.0165	0.0171	0.0258
Antofagasta, Chile	23°37′	0.0604	0.0549	0.0484
Santiago, Chile	33°27′	0.0766	0.0624	0.0514
Puerto Montt, Chile	41°27′	0.0433	0.0495	0.0395
Punta Arenas, Chile	53°08′	0.0268	0.0371	0.0304
South Pole		0.0254		

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[2] A complete discussion of longitudinal effects was given in a summary of 1964 results, see July 1965 *Radiological Health Data*, p. 346.

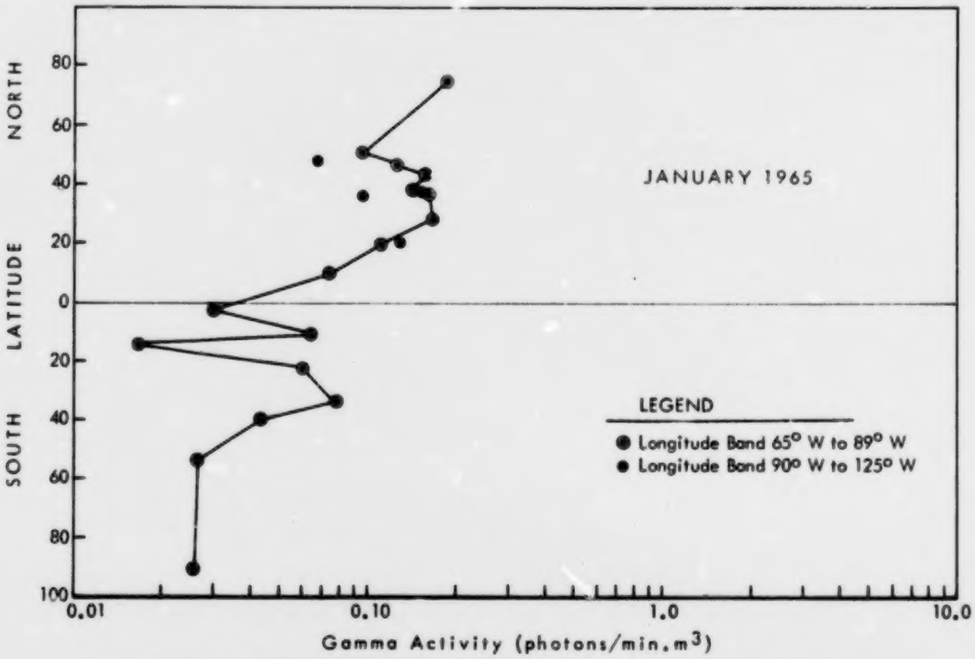

Figure 2. Profile of surface air gamma activity, 80th Meridian stations, January 1965

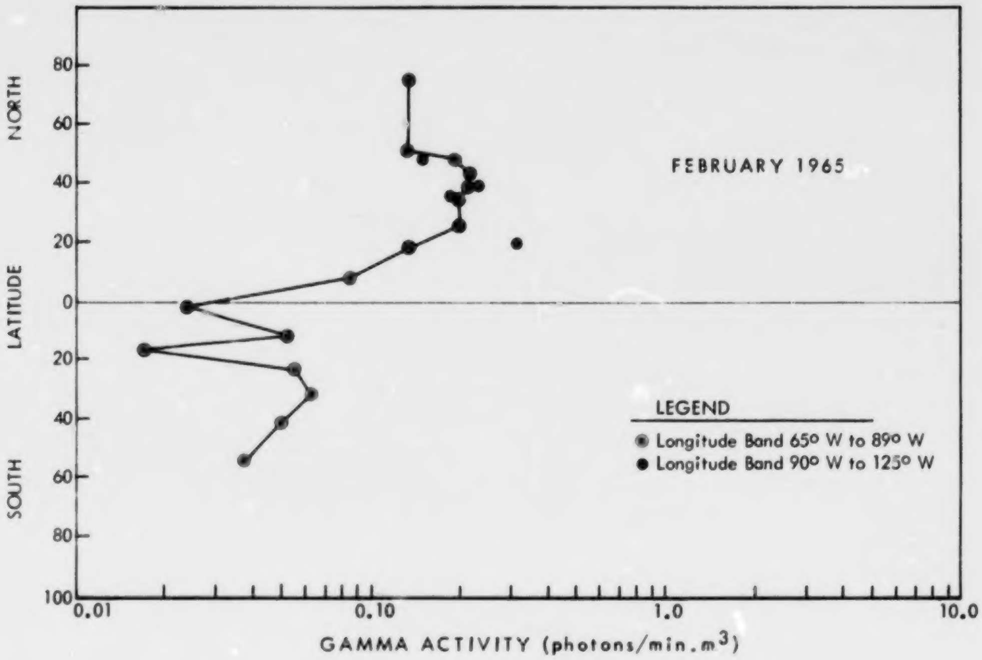

Figure 3. Profile of surface air gamma activity, 80th Meridian stations, February 1965

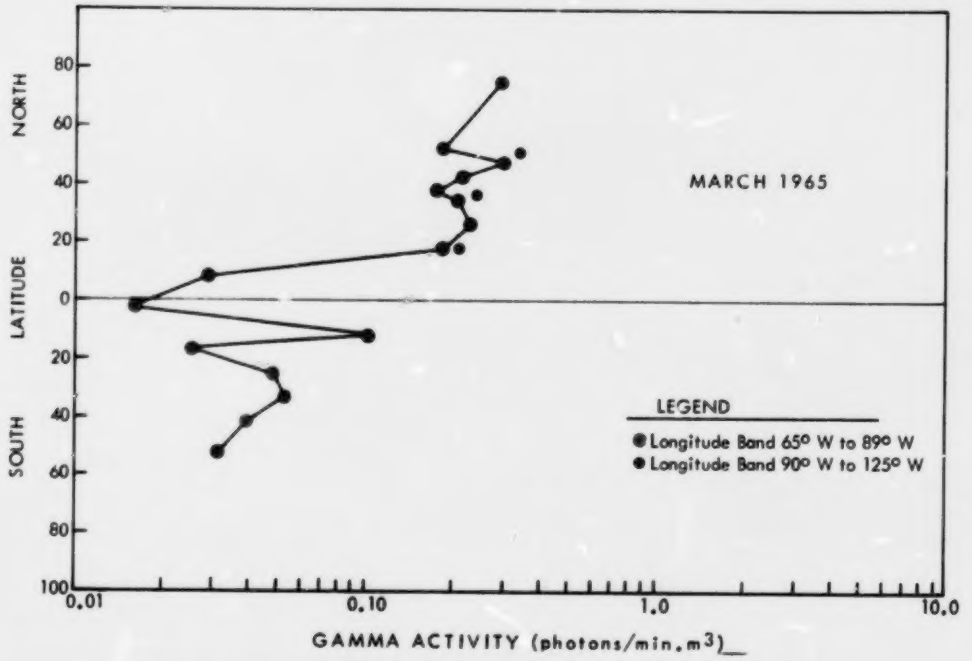

Figure 4. Profile of surface air gamma activity, 80th Meridian stations, March 1965

9

The profiles in figures 2 through 5 reflect a persistent pattern of maxima at midlatitudes in both hemispheres, a low near the Equator, and a minimum at Chacaltaya, Bolivia (16° 21′S). The profile in the Northern Hemisphere for the first quarter of 1965 (figure 5) is similar to the equivalent profile in 1964 but at one-fifth the concentration. The main difference between the two profiles is a less pronounced peak in the concentration at Miami, Florida (25°49′N), during 1965. In the Southern Hemisphere the two profiles are almost identical from 12° southward. The concentration at Guayaquil, Ecuador (2°10′S), in 1964 is about four times the concentration in 1965, even though the concentrations at the other stations in the Southern Hemisphere are almost equal. This may be the result of a slight tropospheric transequatorial exchange between hemispheres. Since the disparity in the activity concentrations between the hemispheres was much greater in early 1964, the effect of a slight transequatorial exchange would be more pronounced at that time than in the following year when the hemispheric concentrations were more nearly equal.

These distributions of activity with latitude are consistent with a model of the atmosphere illustrated in figure 6 (*4*). Much of the activity from the stratospheric reservoir is considered to be transferred through the tropopause gaps. The activity is then transported downward at midlatitudes by the strong and weak circulation cells in each hemisphere which would give rise to maximum activity concentrations in surface air in these areas. As the air is advected equatorward by the strong circulation cell, the activity is scavenged by precipitation and possibly impaction of the radioactive particles on the earth's surface without significant reinforcement from above. This mechanism would provide for low concentrations in equatorial regions. The minimum concentration of activity at Chacaltaya has been attributed to the high altitude of this station (*5–9*), although a similar behavior has not been observed at Mauna Loa.

Average hemispheric gamma concentrations

The average gamma activity concentrations for each month in the Northern and Southern Hemispheres weighted for the volume of surface air in each 10° latitude band are plotted in figure 7 from the beginning of the HASL Surface Air Sampling Program in January 1963. The mean concentration in each 10° latitude band was multiplied by the area of that

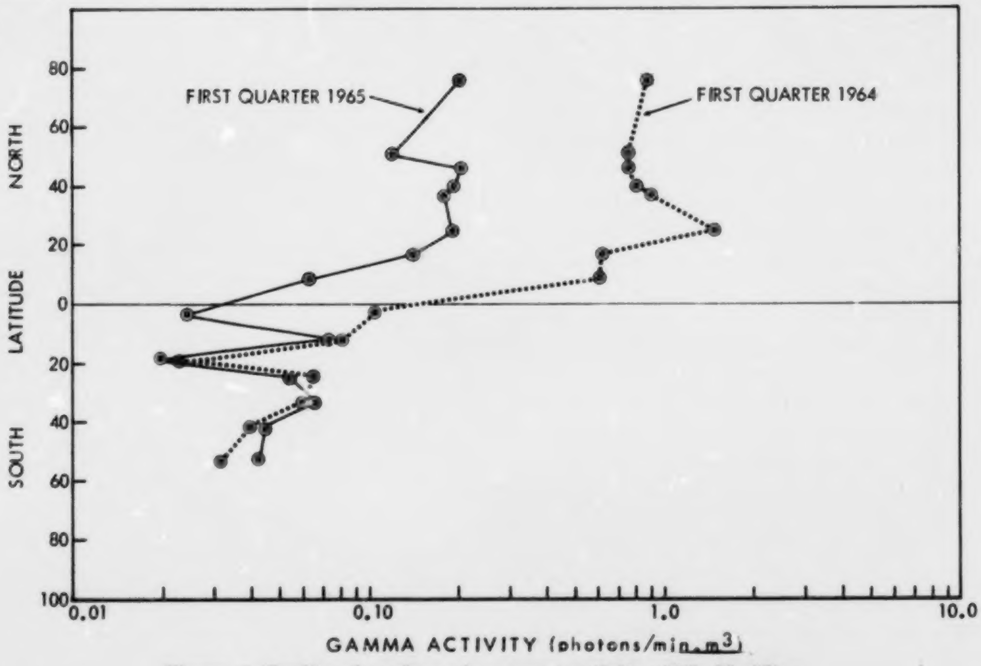

Figure 5. Profile of surface air gamma activity, 80th Meridian stations, first quarters of 1964 and 1965

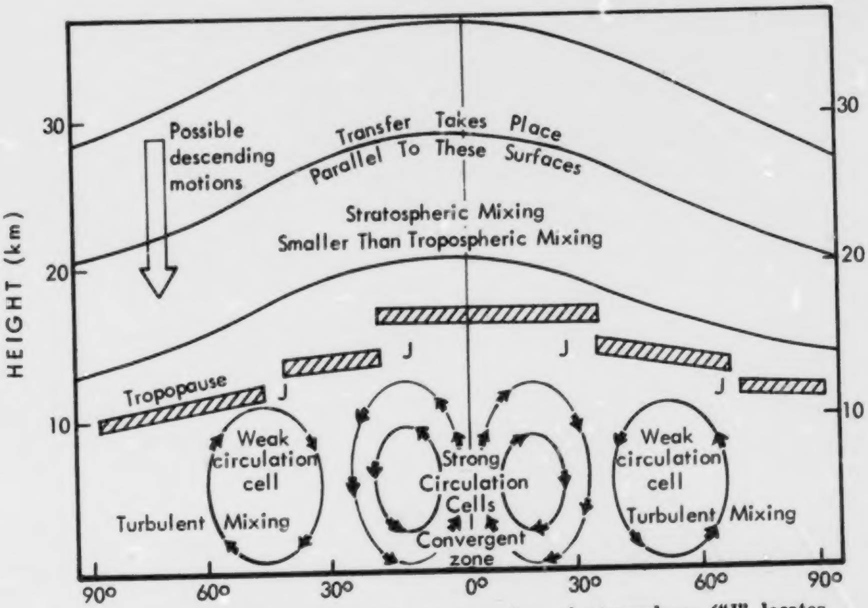
HEIGHT (km)
30
20
10
Possible descending motions
Transfer Takes Place Parallel To These Surfaces
Stratospheric Mixing Smaller Than Tropospheric Mixing
Tropopause
J
Weak circulation cell
Strong Circulation Cells
Convergent zone
Turbulent Mixing
90°
60°
30°
0°
30°
60°
90°

Figure 6. Schematic cross section of atmosphere ("J" locates typical jet stream positions)

10° band. The sum of these products from 0° to 90° was divided by the total area of the hemisphere to give the average hemispheric concentration for the month. In the Northern Hemisphere, the concentrations were assumed to be constant from the station at 76°36′N northward to the Pole. In the Southern Hemisphere, concentrations were determined at the Pole during November and December 1964 and January 1965 from the samples supplied by the U.S. Weather Bureau. Based upon these three measurements, the average relationship between the concentrations at the South Pole and the southernmost station (53°08′S) in the normal HASL network was established. The extrapolation southward from 53°S for months when no measurements at the South Pole are available was based on this average relationship.

In the Northern Hemisphere, spring maxima are obvious in 1963 and 1964, as is the contribution from the mainland Chinese nuclear test of October 16, 1964. Concentrations are building to another peak during the first 3 months of 1965. Assuming that most of the gamma activity in surface air prior to the Chinese test has an apparent production date of October 15, 1962, and making the appropriate corrections for radioactive decay, the half-residence time of debris in the Northern Hemisphere

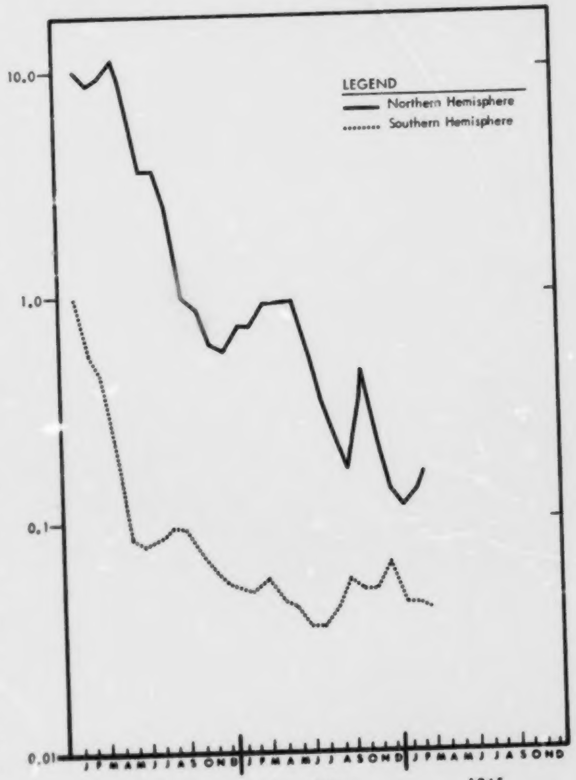

Figure 7. Average hemispheric gamma activity concentrations for 1963 through March 1965

troposphere from April to June 1963 and from July to September 1963 is 54 days. The activity concentrations remained the same during June and July of 1963. From May to September 1964, the half-residence time for the Northern Hemisphere troposphere was 57 days, which is in good agreement with the 1963 value. These calculations make the oversimplifying assumption that no significant amount of activity enters the troposphere from the stratosphere for the remainder of each year after the maximum in the spring peak is reached. Consequently, this value represents a maximum half-residence time for tropospheric debris. This estimate of the half-residence time is a factor of about two higher than previous calculations of 30 days, made during the nuclear test moratorium in 1959 (*10*).

In the Southern Hemisphere, the average troposphere concentrations shown in figure 7 decreased rapidly during the early part of 1963, perhaps as a result of the rainout of debris from the U.S. tests at Johnston Island during late 1962. Again, assuming an October 15, 1962, production date, and making decay corrections, the half-residence time for debris in the troposphere of the Southern Hemisphere from January to May 1963 is about 68 days. While this value is 25 percent greater than the half-residence time determined for the Northern Hemisphere for both 1963 and 1964, there is probably no real significant difference between the two. First of all, the decay correction which greatly affects the calculated half-residence time for debris collected from January to May 1963 is more dependent upon the assumed production date than debris collected late in the year. Secondly, the activity concentration in the Southern Hemisphere during the first half of 1963 appeared to decrease at two different rates. For January and February, the half-residence time appears to be about 110 days. For March through May, the value decreased to about 34 days. Consequently, the uncertainty about the average is large enough to include the estimated half-residence time for the troposphere of the Northern Hemisphere.

There are apparent spring maxima in the Southern Hemisphere during the latter halves of 1963 and 1964, but they are not as clear as in the Northern Hemisphere. From September 1963 to June 1964, the decrease in the average gamma activity concentration of surface air in the Southern Hemisphere is not greatly different from what might be expected from radioactive decay. The assumption that the spring maximum represents the only significant intrusion of activity into the troposphere each year may not apply to the Southern Hemisphere at that time. For example, it has been suggested in this report and earlier (*8*) that there is some transequatorial penetration into the troposphere of the Southern Hemisphere by debris from the troposphere of the Northern Hemisphere. Whatever the explanation, it is evident from figure 7 that there were meteorological parameters operative in the Southern Hemisphere after September 1963 which were not exhibited during the early part of 1963, or at any time in the Northern Hemisphere.

Continuing with the assumption that the apparent production date of most activity in surface air even for the Southern Hemisphere was October 15, 1962, one can compare the activity concentrations during any particular month from one year to the previous year by calculating an appropriate decay factor. These yearly decay factors decrease from 2.4 in October 1964 to 1.8 in March 1965. On this basis, figure 7 shows that the radioactive fallout in the Southern Hemisphere has been greater since September 1964 than it was during the corresponding period of the previous year.

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RADIOCARBON IN THE ENVIRONMENT

J. C. Drobinski, Jr.[1]

SYNOPSIS—Analyses of various samples collected since July 1962 indicate that radiocarbon levels in man and most of his foods have increased about 20 to 30 percent above 1950 levels. This compares to a carbon-14 increase in surface air on the order of 40 to 70 percent.

In July 1962 a research program was initiated at the Northeastern Radiological Health Laboratory by the Research Branch of the Division of Radiological Health to assay foods for carbon-14. It is known that large quantities of this radionuclide are produced when neutrons released in the explosion of nuclear devices are captured by nitrogen atoms (*1*). Man in general is reported to be 18 percent carbon; and DNA, for example, is 37 percent carbon. An increase of carbon-14 in man and his environment involves considerations related to both somatic and genetic effects (*2–7*). It is desirable, therefore, to measure existing levels of this nuclide for evaluation of its potential radiological health hazard. This paper reports specific activities of carbon-14 found in environmental samples. These data are limited in extent and permit only limited correlations between levels in different phases of the environment and in man.

Background

Carbon-14 is generally formed under oxidizing conditions, and therefore exists in the air mainly as carbon dioxide; it enters the photosynthesis process before it reaches animals and man through the food chain.

There is natural or normal carbon-14 produced by the cosmic ray bombardment of nitrogen in the upper atmosphere. A value commonly used for the year 1950, or the "pre-bomb" era, is 14 ± 1 disintegration per minute of carbon-14 per gram of carbon (*8*). Extensive data have been obtained on the carbon-14 content of the atmosphere (*9*), stratosphere (*1*), and the oceans (*10–13*), but only limited data exist on the content of other areas of the environment or biosphere.

Methodology and results

Samples were burned in an atmosphere of oxygen at 800°C. to obtain carbon dioxide and water. A detailed description of methods and apparatus used has been published elsewhere (*14*). The carbon dioxide was further purified after combustion and counted in gas proportional counters. Table 1 lists specific data for individual food items and weekly composited institutional dietary collections (*15–17*). In all cases, the samples represent edible portions.

Table 1. Carbon-14 content of foods

Sample identification	Location	Approximate date of origin	dpm of ^{14}C/g of carbon[b]
Diet[a]			
F-168	Lake Bluff, Ill	July 21, 1963	19.0 ± 2.2
F-171-2	Lake Bluff, Ill	Aug. 25, 1963	17.6 ± 2.6
F-173-2	Parma, Ohio	Sept. 9, 1963	17.5 ± 2.2
F-175	Buffalo, N. Y	[c] Sept. 23, 1963	18.0 ± 2.2
F-175-2	Buffalo, N. Y	[c] Sept. 23, 1963	17.0 ± 2.0
F-177 (9-22)[d]	St. Louis, Mo	[c] Sept. 25, 1963	18.0 ± 2.2
F-179	Lake Bluff, Ill	[c] Sept. 27, 1963	17.2 ± 1.8
F-181 (9-20)[d]	Portland, Maine	Oct. 1, 1963	20.3 ± 2.0
F-183	New York, N. Y	Oct. 1, 1963	18.5 ± 2.2
F-183-(2)	New York, N. Y	Oct. 1, 1963	17.0 ± 2.2
F-192	Parma, Ohio	Nov. 10, 1963	16.8 ± 1.8
F-193	Boston, Mass	Nov. 10, 1963	17.9 ± 2.4
F-194	Lake Bluff, Ill	Nov. 24, 1963	20.7 ± 2.2
F-205	Edenwald, N. Y	Jan. 28, 1964	18.7 ± 2.4
F-203	Boston, Mass	Jan. 6, 1964	14.6 ± 2.0
Oranges	California	Feb. 1963	15.2 ± 2.0
Oranges	Valencia, Fla	July 9, 1963	17.6 ± 2.4
Apples-(5)	Rome, N. Y	Oct. 1962	15.7 ± 2.0
Apples-(2)	Indiana	[c] Jan. 9, 1963	17.9 ± 2.2
Potatoes	Virginia	[c] July 1963	20.6 ± 2.0
Potatoes	Virginia	[c] July 1963	20.7 ± 2.0
Eggs-(2)	Chicago, Ill	[c] July 1963	17.6 ± 1.8
Eggs-(1)	Philadelphia, Pa	July 11, 1963	15.0 ± 2.4
Margarine-(1-2)	Chicago, Ill	Apr. 25, 1963	19.1 ± 2.2
Milk (evap.)	Chicago, Ill	Apr. 1963	19.6 ± 2.0
Sucrose (#5)		Mar. 1962	19.0 ± 2.0
Beef	Sterling, Ill	Jan. 1963	21.3 ± 2.2

[a] Diet samples coded with 'F-numbers' are weekly composites.
[b] Counting error is two sigma.
[c] Date of receipt at NERHL.
[d] Consumers Union sample.

Table 2 lists data derived from human postmortem samples obtained in the Boston area. The average values of 12 matched cases are 17.8, 16.6, 17.6, and 17.7 disintegrations per minute of carbon-14 per gram of carbon for kidney, heart, liver, and blood, respectively. Statistical analysis of the data from these individual cases has shown a significant linear relationship between the specific activities of carbon-14 in kidney and heart (positive cor-

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Table 2. Carbon-14 in human tissue

Autopsy number	Type of sample	Age	Sex	Date of death	dpm of ^{14}C/g of carbon [a]
[b]	Liver-1	[b]	[b]	11/6	16.4±2.6
A-63-194	Liver	71	Female	12/3/63	16.6±2.2
A-63-195	Liver	55	Female	12/3/63	15.7±2.4
A-64-2	Kidney	54	Male	1/20/64	20.8±2.2
A-64-2	Heart	54	Male	1/20/64	19.1±1.8
A-64-2	Liver	54	Male	1/20/64	15.5±2.0
A-64-11	Heart	39	Female	1/20/64	17.0±2.4
A-64-11	Liver	39	Female	1/20/64	18.2±2.0
A-64-14	Heart	64	Female	1/29/64	16.1±2.0
A-64-14	Liver	64	Female	1/29/64	17.8±2.0
A-64-18	Kidney	88	Female	2/7/64	15.5±1.8
A-64-18	Liver	88	Female	2/7/64	15.5±1.6
A-64-19	Kidney	83	Female	2/7/64	16.0±1.8
A-64-19	Liver	83	Female	2/7/64	19.7±1.8
A-64-19	Heart	83	Female	2/7/64	[illegible]±1.6
A-64-20	Kidney	45	Female	2/7/64	16.0±1.8
A-64-20	Heart	45	Female	2/7/64	15.5±2.0
A-64-21	Heart	50	Female	2/7/64	18.0±2.0
A-64-21	Liver	50	Female	2/7/64	15.1±2.0
A-64-24	Liver	63	Male	2/2/64	20.0±2.0
A-64-25	Blood	69	Female	2/3/64	18.3±2.0
A-64-25	Heart	69	Female	2/3/64	13.3±2.0
A-64-25	Liver	69	Female	2/3/64	20.0±2.0
A-64-25	Kidney	69	Female	2/3/64	15.7±2.0
A-64-27	Kidney	43	Male	2/6/64	19.4±2.0
A-64-27	Heart	43	Male	2/6/64	18.2±2.2
A-64-32	Blood	63	Female	2/11/64	16.1±2.2
A-64-32	Kidney	63	Female	2/11/64	17.2±2.0
A-64-38	Kidney	55	Male	3/6/64	15.6±2.0
A-64-38	Heart	55	Male	3/6/64	16.1±2.0
A-64-38	Liver	55	Male	3/6/64	17.9±2.0
A-64-40	Kidney	76	Female	3/9/64	18.1±2.0
A-64-40	Heart	76	Female	3/9/64	17.5±2.0
A-64-40	Liver	76	Female	3/9/64	15.2±2.4
A-64-41	Liver	78	Female	3/10/64	16.7±1.6
A-64-42	Heart	61	Male	3/12/64	19.5±2.0
A-64-44	Kidney	45	Female	3/16/64	14.6±1.6
A-64-44	Heart	45	Female	3/16/64	15.1±2.0
A-64-44	Liver	45	Female	3/16/64	17.4±2.0
A-64-57	Heart	75	Male	4/7/64	16.3±2.0
A-64-57	Kidney	75	Male	4/7/64	17.3±2.0
A-64-58	Heart	76	Female	4/11/64	14.3±2.0
A-64-58	Liver	76	Female	4/11/64	17.0±2.2
A-64-58	Kidney	76	Female	4/11/64	16.9±2.0
A-64-98	Liver	60	Male	6/24/64	18.4±2.1
A-64-103	Kidney	61	Female	7/2/64	22.6±2.0
A-64-103	Heart	61	Female	7/2/64	[c] 18.7±2.0
A-64-103	Heart	61	Female	7/2/64	18.5±2.0
A-64-103	Liver	61	Female	7/2/64	[c] 18.7±2.2
A-64-103	Liver	61	Female	7/2/64	17.3±2.0
A-64-103	Spleen	61	Female	7/2/64	20.2±2.0
A-64-103	Blood	61	Female	7/2/64	18.7±2.0
A-64-126	Kidney	71	Female	8/13/64	18.4±2.0
A-64-129	Liver	47	Male	8/15/64	18.2±2.0
A-64-130	Heart	59	Male	[b]	20.2±2.0
A-64-130	Kidney	59	Male	[b]	20.4±2.0
A-64-130	Spleen	59	Male	[b]	18.6±2.0
A-64-130	Blood	59	Male	[b]	21.8±2.0
A-64-130	Liver	59	Male	[b]	22.1±2.0
V-11(0001)	Bone	7	Male	10/25/64	16.0±2.0

[a] Counting error is two sigma.
[b] Data not available.
[c] Recombusted.

relation coefficient of 0.94 at 5 percent confidence level), but not between the activities in liver and heart.

Table 3 gives the results to date of a study on carbon-14 activities in bull semen obtained from Cornell University and the University of Connecticut. These were chosen because of interest in genetic material.

Table 3. Radioassays of bull semen

Sample identification	Date of origin, 1964	dpm of ^{14}C/g of carbon ([a])
Bull semen #7 (Univ. of Conn.)	Feb.-Mar.	20.3±1.8
Bull semen #1 (Cornell Univ.)	Feb.-Mar.	20.6±2.2 (Station#1) 19.1±2.2 (Station [illegible])
Bull semen #2 (Cornell Univ.)	Apr.-May	20.9±2.0

[a] Counting error is two sigma.

The rate of entry of carbon-14 into human beings is in part determined by levels in surface air. Figure 1 presents the observed levels of carbon-14 in surface air at Winchester, Massachusetts, as previously reported (*18*). Such data can be used in conjunction with measurements of carbon-14 in other segments of the biosphere as a guide in predicting levels in food, animals, and man.

The high levels of fallout radionuclides in Alaskan Eskimos and caribou prompted an investigation of carbon-14 levels in Alaskan caribou. Table 4 depicts the levels found in caribou muscle and rumen contents in April 1964.

Table 4. Carbon-14 in Alaskan caribou [a] muscle and rumen contents, April 1964

Sample identification	Date of collection, 1964	dpm of ^{14}C/g of carbon ([b])	Percent Δ ^{14}C ([c])
Muscle (61-822)	April	19.7±2.0	41
Muscle (61-824)	April	18.3±2.0	31
Muscle (61-824) [d]	April	20.2±2.0	44
Muscle (61-826)	April	21.2±2.0	51
Muscle (61-826) [d]	April	19.8±2.0	41
Rumen contents (65-827)	April	18.0±2.0	29
Rumen contents (65-829)	April	15.2±2.0	8
Rumen contents (65-831)	April	19.8±1.6	41

[a] Peninsula caribou—2 years old.
[b] Counting error is two sigma.
[c] Percent above natural radioactivity of 14±1 dpm of ^{14}C/g of carbon.
[d] Radioassay by Geochron Laboratories, Boston, Massachusetts.

The arithmetic means of carbon-14 levels found in the segments of the environment investigated are presented in table 5. Present levels in man and in foods are the same as those present in air in 1962 (*18*). Of the averages in table 5, those for grazing animals appear closer to those currently observed in the atmosphere, but this may not be significant because of counting errors and the small number of samples analyzed. These data, considered in relation to atmospheric trends, are helpful in the selection of samples to ascertain or estimate

Table 5. Summary of carbon-14 analytical results for various environmental samples

Type of sample	Number of samples	dpm of ^{14}C/g of carbon	Percent Δ ^{14}C [a]
CO_2 in air	25	22.0	57
Semen [b]	4	20.2	44
Caribou muscle	5	19.8	41
Blood [c]	4	18.7	34
Food [c]	27	18.1	29
Kidney [c]	15	17.6	26
Liver [c]	21	17.6	26
Caribou rumen contents	3	17.7	26
Heart [c]	16	16.9	21

[a] Percent above natural level of 14±1 dpm/g carbon in 1950, third column data not corrected for ^{13}C/^{12}C isotopic ratio.
[b] Bull.
[c] Human.

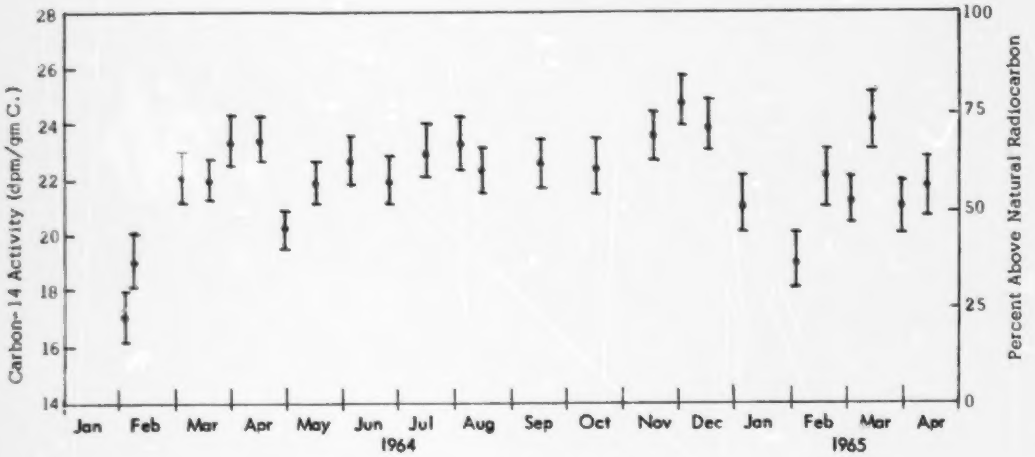

Figure 1. Carbon-14 levels in surface air, Winchester, Massachusetts

the added levels of activity that have entered and that will enter man and his environment. Libby and his associates have reported the results of limited studies on replacement rates for human tissue from atmospheric radiocarbon, and discussed the time lag between the rise in atmospheric radiocarbon and the appearance of elevated levels in food and in man (*19*). Further studies of these relationships may help in the development of models for predicting radiocarbon concentrations in human tissues.

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Data

Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the United States population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analysis of the total diet or of representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other, but they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the International Commission on Radiological Protection (*4, 5*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross section of routine sampling programs which may be considered of a continuing nature. Routine sampling has been defined as one or more samples collected per month.

NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk. Data from the Pasteurized Milk Network (U.S.), Canadian Milk Network, and Pan American Milk Network are presented below.

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1. Pasteurized Milk Network
September 1965

Division of Radiological Health and Division of Environmental Engineering and Food Protection, PHS

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk levels in every State. In addition, milk is sampled in the Canal Zone and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 *Radiological Health Data* (*5*).

The results for September 1965 and third quarter of 1965 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*5*), averages were calculated using one-half the minimum detectable value; however, for iodine-131 and barium-140, zero was used for averaging purposes when concentrations were below the minimum detectable levels.

For comparative purposes, distributions of strontium-90 and cesium-137 are presented in tables 2 and 3 for April through September 1965. The average monthly strontium-90 concentrations in pasteurized milk from selected cities in the sampling program are presented in figure 2.

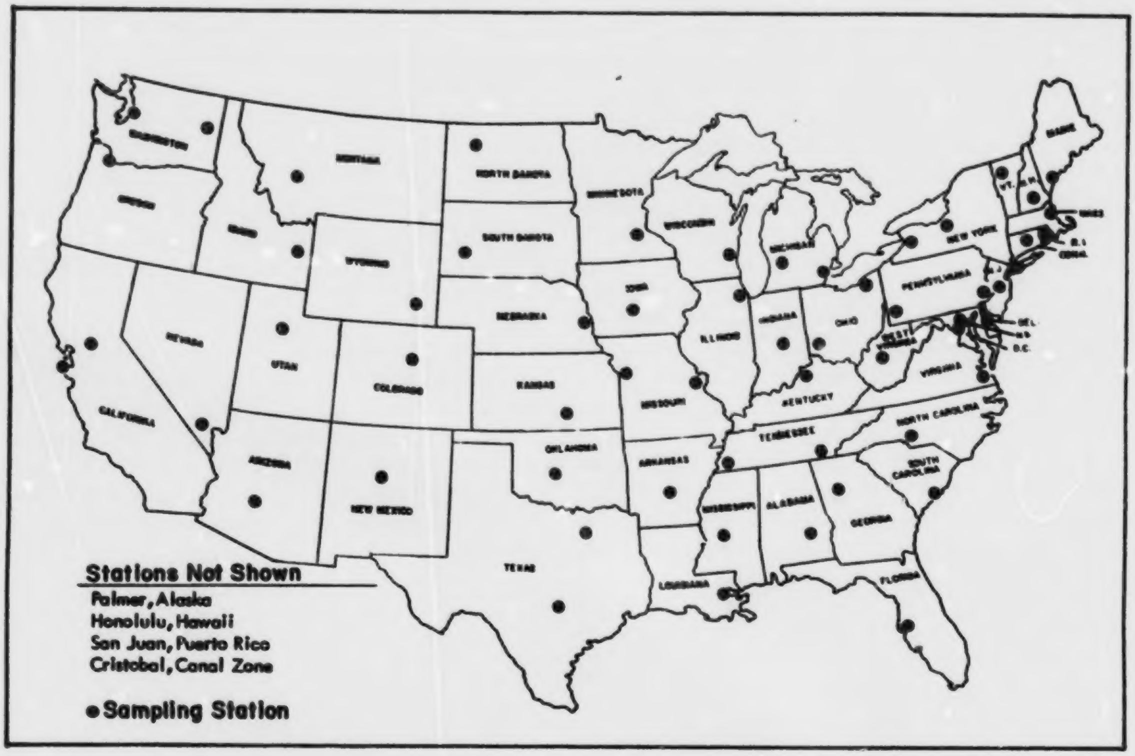

Figure 1. Pasteurized Milk Network sampling stations

Table 1. Average concentrations of stable nuclides and radionuclides in pasteurized milk for the third quarter 1965 and September 1965 [a]

Sampling locations	Calcium (g/liter)		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)		Iodine-131 (pCi/liter)	
	Third quarter	Sept. average	Third quarter	Sept. average	Third quarter	Sept. average	Third quarter	Sept. average	Third quarter	Sept. average
Ala: Montgomery	1.14	1.14	<5	<5	14	14	40	35	0	0
Alaska: Palmer	1.22	1.24	<5	<5	15	14	50	60	0	0
Ariz: Phoenix	1.22	1.24	<5	<5	4	3	20	20	0	0
Ark: Little Rock	1.14	1.17	5	<5	28	28	50	40	0	0
Calif: Sacramento	1.28	1.34	<5	<5	5	4	25	25	0	0
San Francisco	1.25	1.29	<5	<5	5	3	20	20	0	0
C. Z: Cristobal	1.10	1.11	<5	<6	4	4	30	30	0	0
Colo: Denver	1.28	1.28	5	<5	14	11	40	35	0	10
Conn: Hartford	1.09	1.08	<5	<5	13	12	50	40	0	0
Del: Wilmington	1.11	1.10	<5	<5	15	14	40	30	0	0
D. C: Washington	1.13	1.15	<5	<5	13	13	30	25	0	0
Fla: Tampa	1.16	1.16	<5	<5	12	13	175	165	0	0
Ga: Atlanta	1.14	1.15	<5	<5	20	20	55	45	0	0
Hawaii: Honolulu	1.16	1.13	<5	<5	6	5	40	45	0	0
Idaho: Idaho Falls	1.27	1.25	<5	<5	16	9	50	40	0	0
Ill: Chicago	1.11	1.11	<5	<5	11	11	35	30	0	0
Ind: Indianapolis	1.11	1.10	<5	<5	12	11	25	20	0	0
Iowa: Des Moines	1.23	1.28	<5	<5	16	14	30	30	0	0
Kans: Wichita	1.19	1.16	<5	<5	14	9	25	20	0	0
Ky: Louisville	1.12	1.15	5	<5	18	17	25	20	0	0
La: New Orleans	1.18	1.19	<5	<5	33	31	60	55	0	0
Maine: Portland	1.11	1.11	5	<5	20	16	90	70	0	0
Md: Baltimore	1.11	1.12	<5	<5	15	14	40	30	0	0
Mass: Boston	1.10	1.09	5	<5	19	17	80	60	0	0
Mich: Detroit	1.09	1.08	<5	<5	11	10	35	30	0	0
Grand Rapids	1.13	1.11	<5	<5	14	13	45	40	0	0
Minn: Minneapolis	1.28	1.28	5	<5	23	19	50	40	0	0
Miss: Jackson	1.18	1.18	<5	<5	25	22	40	35	0	0
Mo: Kansas City	1.21	1.27	5	<5	18	18	25	20	0	0
St. Louis	1.22	1.25	5	<5	16	15	25	25	0	10
Mont: Helena	1.27	1.32	5	<5	18	17	55	45	0	0
Nebr: Omaha	1.22	1.30	<5	<5	16	16	30	30	0	0
Nev: Las Vegas	1.20	1.15	<5	<5	5	3	20	15	0	0
N. H: Manchester	1.11	1.09	<5	<5	21	18	105	85	0	0
N. J: Trenton	1.09	1.08	<5	<5	14	12	40	30	0	0
N. Mex: Albuquerque	1.24	1.22	<5	<5	6	5	20	15	0	10
N. Y: Buffalo	1.09	1.06	<5	<5	11	11	45	35	0	0
New York	1.09	1.08	<5	<5	17	15	55	45	0	0
Syracuse	1.09	1.08	5	<5	12	12	40	35	0	0
N. C: Charlotte	1.13	1.14	<5	<5	24	23	40	35	0	0
N. Dak: Minot	1.28	1.27	10	<5	31	28	55	50	0	0
Ohio: Cincinnati	1.11	1.11	<5	<5	13	12	25	20	0	0
Cleveland	1.10	1.08	5	<5	13	13	35	25	0	0
Okla: Oklahoma City	1.11	1.14	<5	<5	14	12	25	20	0	0
Ore: Portland	1.28	1.32	<5	<5	14	12	50	45	0	10
Pa: Philadelphia	1.08	1.09	<5	<5	13	12	35	30	0	0
Pittsburgh	1.11	1.09	5	<5	20	18	50	40	0	0
P. R: San Juan	1.13	1.14	<5	<5	9	9	40	30	0	0
R. I: Providence	1.10	1.07	<5	<5	16	15	65	50	0	0
S. C: Charleston	1.14	1.14	<5	<5	23	23	70	70	0	0
S. Dak: Rapid City	1.04	1.04	10	<5	20	17	50	50	0	0
Tenn: Chattanooga	1.16	1.19	<5	<5	26	25	40	30	0	0
Memphis	1.15	1.18	5	<5	20	19	25	20	0	0
Tex: Austin	1.12	1.11	<5	<5	5	5	20	15	0	0
Dallas	1.11	1.12	<5	<5	12	11	25	20	0	0
Utah: Salt Lake City	1.36	1.30	<5	<5	12	13	55	40	0	0
Vt: Burlington	1.11	1.12	<5	<5	17	15	65	50	0	0
Va: Norfolk	1.13	1.13	<5	<5	17	16	40	30	0	0
Wash: Seattle	1.28	1.35	<5	<5	18	16	70	60	0	10
Spokane	1.33	1.35	<5	<5	18	14	50	40	0	0
W. Va: Charleston	1.12	1.14	<5	<5	18	17	25	20	0	0
Wis: Milwaukee	1.17	1.19	<5	<5	11	12	40	40	0	0
Wyo: Laramie	1.28	1.35	<5	<5	14	11	50	50	0	0
Network average	1.16	1.17	<5	<5	15.3	14.0	44	38	0	1

[a] All barium-140 values less than detectable levels.

Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network stations, April–September 1965 and September 1964

Strontium-90 (pCi/liter)	Number of stations						
	1965						1964
	Apr	May	June	July	Aug	Sept	Sept
Under 10	5	4	7	8	10	11	8
10–19	23	26	21	34	41	44	27
20–29	27	25	29	18	11	7	20
30–39	5	5	4	3	1	1	6
40–49	2	2	2	0	0	0	2
50–59	0	0	0	0	0	0	0
60–69	1	1	0	0	0	0	0
70–79	0	0	0	0	0	0	0

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, April–September 1965 and September 1964

Cesium-137 (pCi/liter)	Number of stations						
	1965						1964
	Apr	May	June	July	Aug	Sept	Sept
Under 50	7	17	19	34	45	50	14
50–99	35	31	38	25	16	12	33
100–149	18	13	5	3	1	0	13
150–199	3	2	1	1	1	1	2
200–249	0	0	0	0	0	0	1
250–299	0	0	0	0	0	0	0

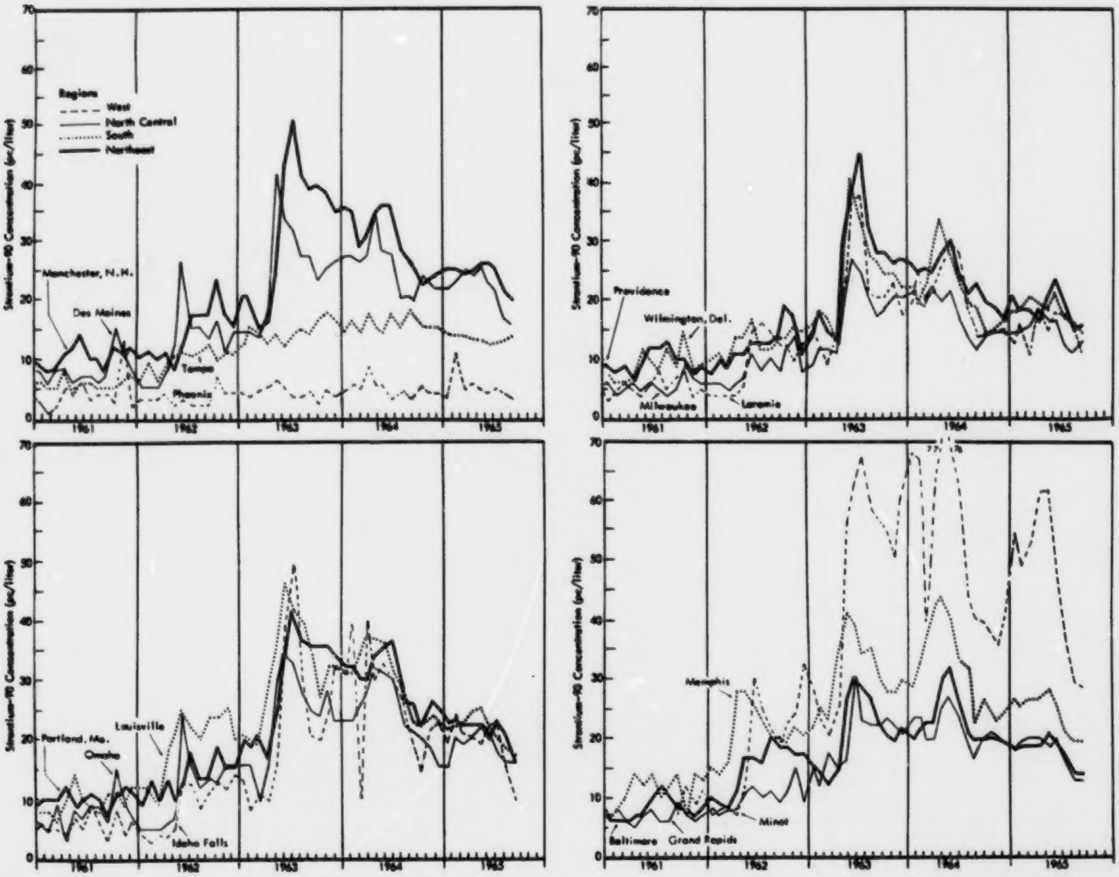

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961–July 1965

2. Canadian Milk Network[1]
September 1965

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data* (*6*).

The September 1965 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 4. Iodine–131 and strontium–89 concentrations were below minimum detectable levels.

Table 4. Stable elements and radionuclides in Canadian whole milk, September 1965

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.15	1.6	18.7	62
Edmonton	1.16	1.6	23.7	80
Ft. William	1.13	1.6	27.4	98
Fredericton	1.14	1.6	30.4	78
Halifax	1.13	1.6	26.1	60
Montreal	1.09	1.6	16.9	41
Ottawa	1.13	1.5	15.1	53
Quebec	1.10	1.6	23.2	71
Regina	1.08	1.6	17.3	38
St. John's, Nfld	1.03	1.4	40.4	129
Saskatoon	1.16	1.6	23.8	62
Sault Ste. Marie	1.00	1.6	30.6	87
Toronto	1.13	1.5	10.8	31
Vancouver	1.16	1.5	20.0	83
Windsor	1.10	1.6	7.8	22
Winnipeg	1.09	1.6	18.8	52
Average	1.11	1.6	21.9	65

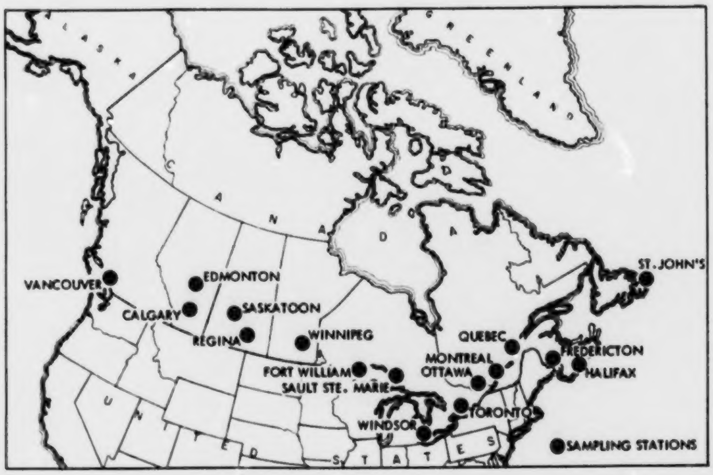

Figure 3. Canadian milk sampling stations

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[1] Prepared from October 1965 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Milk Sampling Program September 1965

Pan American Health Organization and Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries. Sampling locations are shown in figure 4. Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1965 issue of *Radiological Health Data* (*7*).

Table 5 presents stable calcium and potassium, strontium-89, strontium-90, and cesium-137 monthly average concentrations. The monthly average iodine-131 and barium-140 concentrations in milk were less than 10 pCi/liter.

Table 5. Stable element and radionuclide concentrations in milk, PAHO, September 1965

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Canal Zone:					
Cristobal	1.11	1.5	<5	4	30
Jamaica:					
Kingston	1.11	1.36	<5	8	175
Mandeville	NS	NS	NS	NS	NS
Montego Bay	NS	NS	NS	NS	NS
Puerto Rico:					
San Juan	1.14	1.5	<5	9	30
Venezuela:					
Caracas	1.16	1.54	<5	5	20

NS indicates no sample collected.

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(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961). Price 20 cents.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action guides for strontium-89, strontium-90, and cesium-137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965). Price 30 cents.

(*4*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 3. Pergamon Press (1965).

(*5*) PUBLIC HEALTH SERVICE. Milk surveillance, Pasteurized Milk Network, August 1965. Division of Radiological Health and Division of Environmental Engineering and Food Protection. Rad Health Data 6:677-681 (December 1965).

(*6*) RADIATION PROTECTION DIVISION, DEPARTMENT OF NATIONAL HEALTH AND WELFARE, OTTAWA, CANADA. Canadian Milk Network, August 1965. Rad Health Data 6:685-686 (December 1965).

(*7*) PAN AMERICAN HEALTH ORGANIZATION, and PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1965. Rad Health Data 6:687 (December 1965).

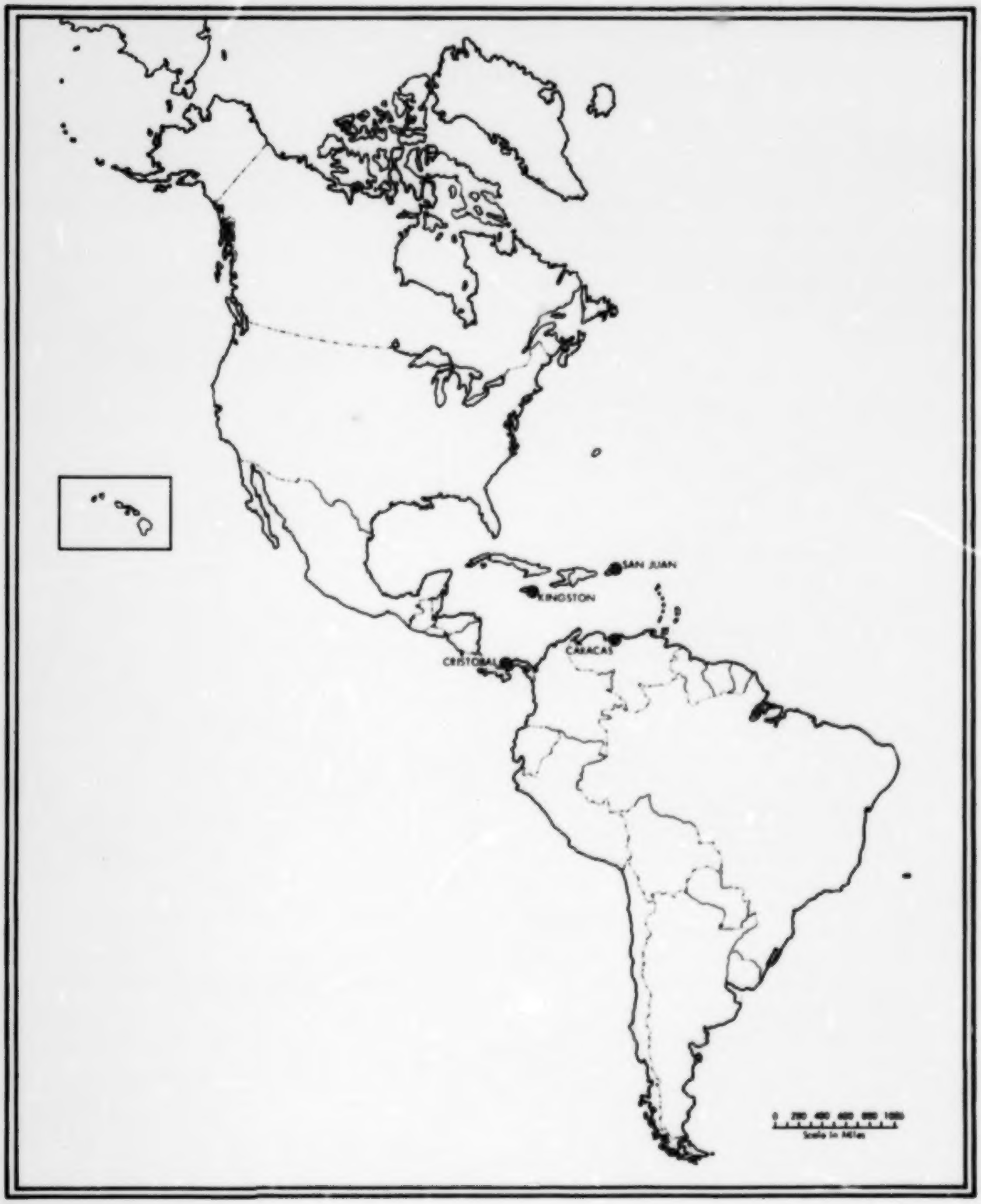
SAN JUAN
KINGSTON
CARACAS
CRISTOBAL
0 200 400 600 800 1000
Scale in Miles

Figure 4. Pan American Milk Network sampling stations

STATE MILK SURVEILLANCE ACTIVITIES

The sampling and analysis for radionuclides in milk is an integral part of comprehensive environmental surveillance programs. A number of States have developed milk surveillance programs to satisfy their needs. While there is variation between programs, to a considerable extent the data produced complements that from Federal milk surveillance activities. Data from selected State milk surveillance activities are presented below. The results presented, while not all-inclusive, are representative of current State milk surveillance activities.

1. Florida Milk Network
January–June 1965

Division of Radiological and
Occupational Health
Florida State Board of Health

The Florida State Board of Health began sampling raw milk for iodine-131 analysis in two major areas of the State in November 1962. The program has since been expanded to include the analysis of raw milk for strontium-89, strontium-90, iodine-131, and cesium-137 from the six areas shown in figure 1. Samples for iodine-131 analysis are taken from tank trucks or selected farms. When iodine-131 was detectable in milk, samples were collected weekly. In the interest of maintaining an active standby capability, samples are now collected and analyzed for this nuclide on a monthly basis.

For complete radiochemical analyses, the six regional State Board of Health Laboratories prepare monthly composite milk samples for each region by combining random samples from 10 percent of the dairy farms selected. These composite samples are sent to the State Radiological Health Laboratory in Orlando.

Strontium-89 and strontium-90 are determined by the ion exchange method developed by Porter *et al.* (*1*) Iodine-131 and cesium-137 are determined by gamma scintillation spectrometry (*2*).

Cesium-137 concentrations for January through June 1965 are presented in table 1. Iodine-131 concentrations were below detectable levels. Strontium-89 and strontium-90 results were not reported for this period.

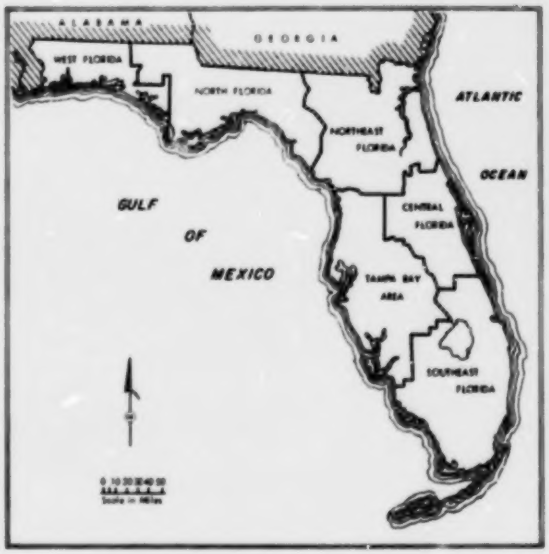

Figure 1. Florida milk sampling areas

Table 1. Cesium-137 in Florida raw milk
January–June 1965

Month	Concentration (pCi/liter)						
	West Florida	North Florida	Northeast Florida	Central Florida	Tampa Florida	Southeast Florida	Average
January	179	93	112	225	89	183	147
February	150	79	97	263	61	154	134
March	96	110	134	177	102	164	141
April	91	103	182	175	157	156	144
May	99	96	198	221	161	134	151
June	71	148	148	242	153	150	152
Average	114	105	145	188	130	156	144

2. Minnesota Milk Network January–June 1965

Division of Environmental Health
Minnesota Department of Health

In September 1958, the Minnesota Department of Health initiated a pasteurized milk network to monitor strontium-90 concentrations. Presently, monthly samples are collected from eight sampling locations in milksheds geographically the same as the Minnesota health districts (figure 2) for strontium-90, iodine-131, and cesium-137 analyses. One-liter samples of processed Grade-A fluid milk are collected at bottling machines in pasteurization plants. The samples are customarily collected in the cities where the Minnesota Health District offices are located. However, it is sometimes convenient to collect at other locations. Such samples are considered representative of the district concerned.

Strontium-90 concentrations are determined radiochemically, while iodine-131 and cesium-137 concentrations are determined by gamma scintillation spectrometry. The analytical procedures are presented in the semiannual report of the Minnesota Department of Health and Rural Cooperative Power Association (*3*).

Strontium-90 (table 2), iodine-131 (table 3), and cesium-137 (table 4) concentrations in milk are given for January through June 1965. The strontium-90, cesium-137, and iodine-131 concentrations in Minnesota pasteurized milk are presented graphically by milkshed in figure 3 for the period 1962–June 1965.

Table 2. Strontium-90 concentrations in Minnesota milk January–June 1965

Sampling locations	Strontium-90 (pCi/liter)						
	Jan.	Feb.	Mar.	Apr.	May	June	Average
Bemidji	32	34	37	34	38	39	36
Mankato	12	12	12	15	12	16	13
Rochester	16	18	15	17	15	14	16
Duluth	29	39	36	39	36	32	35
Worthington	14	13	15	13	13	13	14
Minneapolis	24	22	21	26	27	23	24
Fergus Falls	21	21	22	18	20	19	20
Little Falls	[a] 37	20	23	19	[b] 18	22	23
Average	26	22	23	23	22	22	23

[a] Sample collected at Brainerd, near Little Falls.
[b] Sample collected at St. Cloud, near Little Falls.

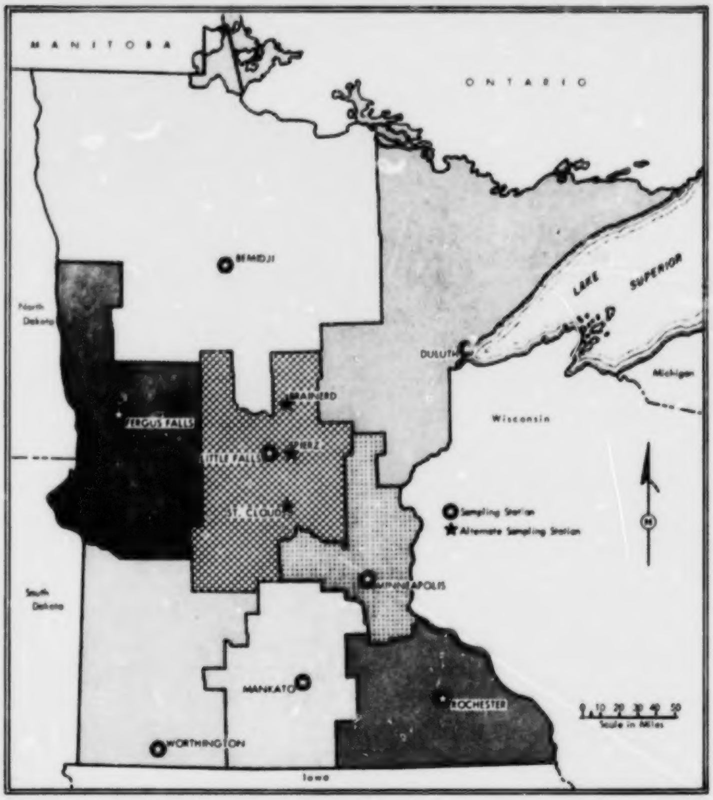
MANITOBA
ONTARIO
BEMIDJI
North Dakota
LAKE SUPERIOR
DULUTH
Michigan
Wisconsin
BRAINERD
FERGUS FALLS
LITTLE FALLS
ST. CLOUD
Sampling Station
Alternate Sampling Station
MINNEAPOLIS
South Dakota
MANKATO
ROCHESTER
0 10 20 30 40 50
Scale in Miles
WORTHINGTON
Iowa

Figure 2. Minnesota milk sampling locations

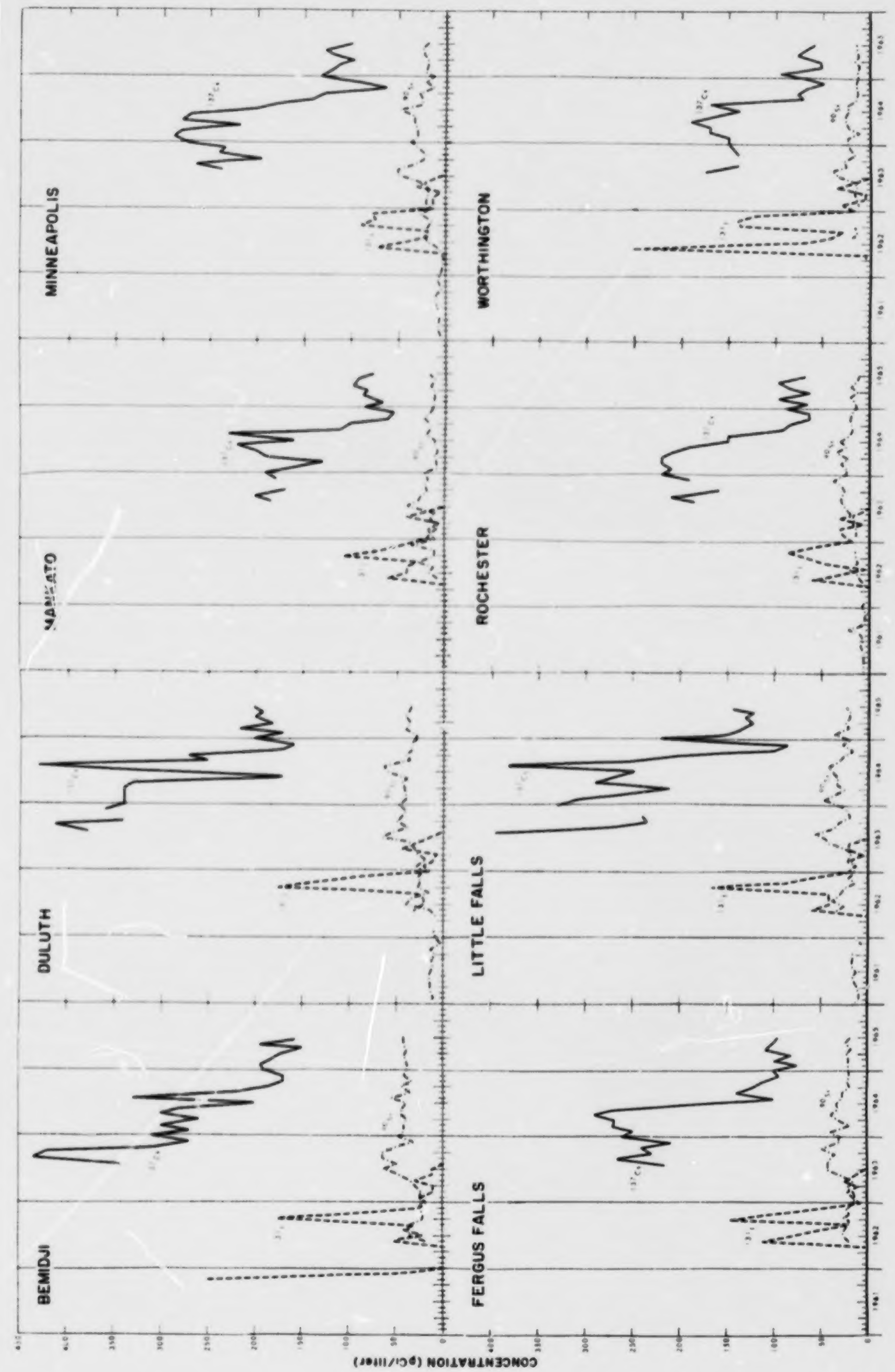

Figure 3. Radionuclide concentrations in Minnesota milk, 1961–June 1965

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Table 3. Iodine-131 concentrations in Minnesota milk January–June, 1965

Collection point	Collection date	Iodine-131 (pCi/liter)
Bemidji	6/ 7/65	31
Mankato	6/ 3/65	53
Rochester	6/ 7/65	66
Rochester	6/14/65	<10
Duluth	6/ 7/65	37
Worthington	5/31/65	13
Worthington	6/ 1/65	31
Minneapolis	6/ 1/65	70
Minneapolis	6/ 8/65	50
Minneapolis	6/15/65	36
Fergus Falls	6/ 7/65	66
Little Falls	6/ 4/65	37

Note: The remaining 47 samples analyzed showed less than 10 pCi/liter.

Table 4. Cesium-137 concentrations in Minnesota milk January–June 1965

Collection point	Cesium-137 (pCi/liter)						
	Jan.	Feb.	Mar.	Apr.	May	June	Average [a]
Bemidji	190	180	170	150	190	160	175
Mankato	65	88	82	97	94	74	85
Rochester	66	97	64	82	97	65	80
Duluth	170	230	180	200	190	200	195
Worthington	94	51	52	81	71	62	70
Minneapolis	120	110	95	120	130	100	95
Fergus Falls	75	100	82	110	100	94	95
Little Falls	[b] 155	134	120	130	[c] 120	144	135
Average	115	125	110	120	125	110	115

[a] To nearest 5 pCi/liter.
[b] Sample collected at Brainerd, near Little Falls.
[c] Sample collected at St. Cloud, near Little Falls.

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3. New York Milk Network April–June 1965

Division of Environmental Health Services
Department of Health, State of New York

Pasteurized milk samples collected routinely from six cities (figure 4) are analyzed for strontium–89, strontium–90, iodine–131, and barium-lanthanum–140 by the New York State Department of Health. At Buffalo, Newburgh, and Syracuse milk, samples from processing plants are collected daily and composited weekly for radiochemical analyses. At Massena, samples are composited biweekly, while in New York, a milk sample representing the total milk supply for one day is obtained and composited weekly for analysis. The Albany sample, taken at a marketing point, is analyzed daily for iodine–131 and other gamma-emitting radionuclides before being composited into a weekly sample. In the event that any sample contains iodine–131 concentrations exceeding 100 pCi/liter, increased surveillance is undertaken.

Gamma-emitting radionuclides in milk are determined by scintillation spectrometry and the application of a matrix method of analysis (*4*) to the resultant spectral data.

The analytical procedure for determining strontium–89 and strontium–90 concentrations employs an ion exchange system similar to that developed by Porter *et al.* (*5*).

The monthly average radionuclide concentrations of strontium–89 and strontium–90 (table 5), and iodine–131 and cesium–137 (table 6),

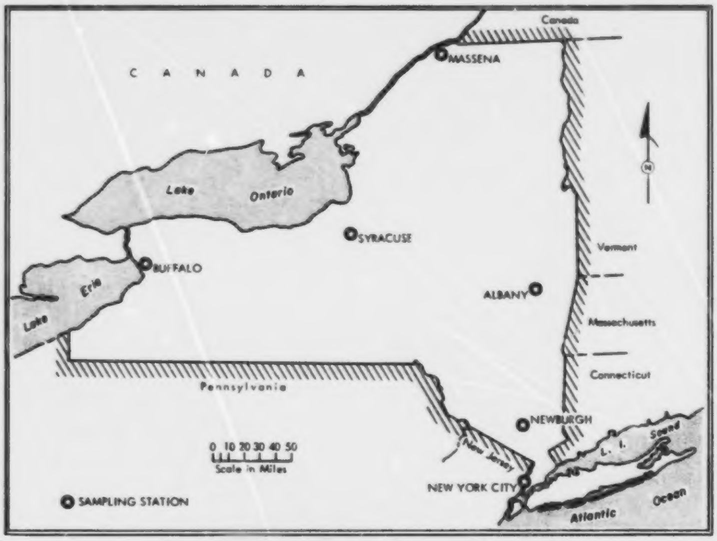

Figure 4. New York milk sampling stations

Table 5. Strontium-89 and strontium-90 concentrations in New York milk, April–June 1965

Sampling locations	Strontium-89, pCi/liter			Strontium-90, pCi/liter		
	April	May	June	April	May	June
Albany	<3	<3	4	15	15	19
Ashford	<3	NS	NS	21	NS	NS
Bedford	<3	3	7	22	28	30
Buffalo	<3	<3	6	16	39	14
Clarktown	NA	<3	<3	NA	8	6
East Otto	<3	NS	NS	14	NS	NS
Massena	<3	<3	4	20	20	20
Middleburg	<3	<3	5	15	19	15
Mount Pleasant	<3	<3	3	11	11	13
Newburgh	<3	<3	6	15	14	15
New York City	<3	<3	6	20	19	23
Oyster Bay	<3	<3	<3	16	16	14
Syracuse	<3	<3	4	13	9	9
Yaphank	<3	NS	NS	11	NS	NS
Yorkshire	<3	NS	NS	17	NS	NS
Yorktown	<3	NA	5	23	NA	18
Average	<3	<3	<3	16.4	15.8	15.6

Key to symbols: NA, no analysis
NS, no sample

are shown for April through June 1965. Cesium–137 and iodine–131 concentrations since September 1961 are presented graphically in figure 5.

Table 6. Iodine-131 and cesium-137 concentrations in New York milk, April–June 1965

Sampling locations	Iodine-131, pCi/liter			Cesium-137, pCi/liter		
	April	May	June	April	May	June
Albany	<20	<20	22	67	58	30
Ashford	<20	NS	NS	112	NS	NS
Bedford	<20	32	30	66	42	46
Buffalo	<20	<20	<20	78	67	38
Clarkstown	<20	<20	26	57	54	43
East Otto	<20	NS	NS	99	NS	NS
Massena	<20	30	<20	112	76	70
Middleburg	<20	24	64	64	69	24
Mount Pleasant	<20	<20	<20	65	46	39
Newburgh	<20	<20	25	57	60	37
New York	<20	<20	25	80	62	48
Oyster Bay	<20	<20	<20	94	74	66
Syracuse	<20	23	35	61	41	28
Yaphank	<20	NS	NS	67	NS	NS
Yorkshire	<20	NS	NS	86	NS	NS
Yorktown	<20	<20	<20	70	64	48
Average	<20	<20	<20	72	71	62

NS, no sample.

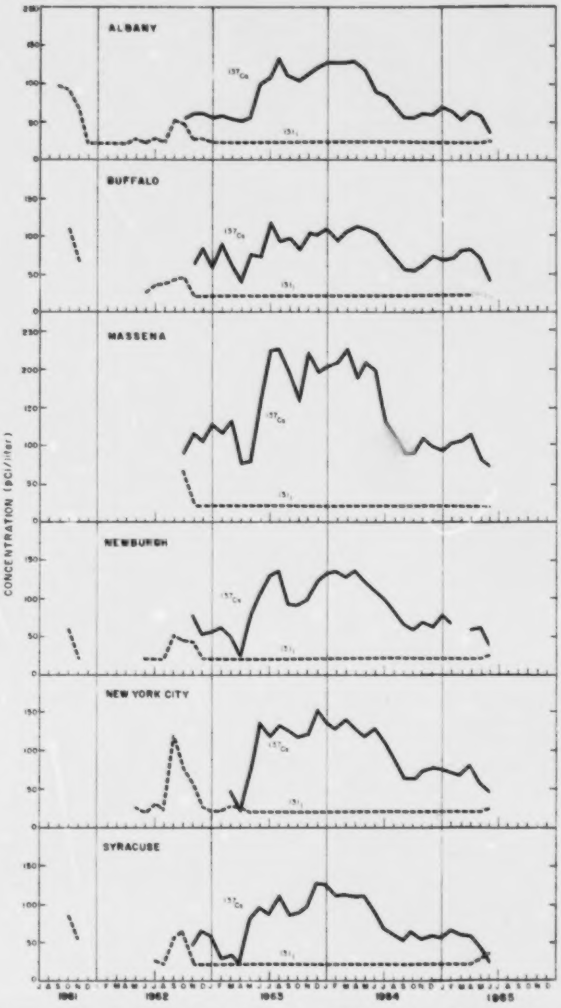

Figure 5. Cesium–137 and iodine–131 in New York milk, September 1961 to June 1965

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(2) DIVISION OF RADIOLOGICAL AND OCCUPATIONAL HEALTH, FLORIDA STATE BOARD OF HEALTH. Florida Milk Network, July–December 1964. Rad Health Data 6:611–612 (November 1965).

(3) MINNESOTA DEPARTMENT OF HEALTH AND RURAL COOPERATIVE POWER ASSOCIATION. Survey of environmental radioactivity, January–June 1965. Coo–615–17 (August 1965).

(4) KAHN, B., G. K. MURTHY, C. PORTER, G. R. HAGEE, G. J. KARCHES, and A. S. GOLDIN. Rapid methods for estimating fission product concentrations in milk. PHS Publication No. 999–R–2 (March 1963). Single copies available on request from Public Inquiries Branch, PHS, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

(5) PORTER, C., and B. KAHN. Improved determination of strontium–90 in milk by an ion exchange method. Anal Chem 36:676–678 (March 1964).

Other State Milk Network coverage:

Milk network	*Period reported*	*Last presented*
California	April–June 1965	*December 1965*
Colorado	October–December 1964	*April 1965*
Connecticut	January–March 1965	*August 1965*
Florida	July–December 1964	*November 1965*
Indiana	April–June 1965	*November 1965*
Michigan	January–June 1965	*November 1965*
Minnesota	July–December 1964	*July 1965*
Oklahoma	March–July 1965	*October 1965*
Oregon	January–March 1965	*August 1965*
New York	January–March 1965	*November 1965*
Pennsylvania	April–June 1965	*November 1965*
Texas	January–March 1965	*October 1965*
Washington	January–June 1965	*November 1965*

FOOD AND DIET SURVEILLANCE

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. While not based on probability sampling, these networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides.

Previous coverage:

Program	*Period reported*	*Last presented*
Institutional Total Diet	January–March 1965	*October 1965*
Tri-City Diet	February–April 1965	*December 1965*
Teenage Diet	February–November 1964	*July 1965*
California Diet	November–December 1964	*December 1965*
Connecticut Standard Diet	March 1963–December 1964	*July 1965*
Consumers Union	February 1963–June 1964	*December 1965*

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Section II. Water

The Public Health Service and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and/or treated (drinking) water. Most of these programs include determinations of gross alpha and gross beta radioactivity and/or specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the values secured with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for radium–226 and strontium–90 as 3 pCi/liter and 10 pCi/liter, respectively, without considering other sources of radioactivity. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the limits recommended by FRC for control action. In the known absence[1] of strontium–90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium–90, respectively.

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, JULY 1965

Division of Water Supply and Pollution Control, Public Health Service

Since 1957 the Public Health Service Water Pollution Surveillance System has included the monitoring of levels of radioactivity in surface waters in the United States as part of its water quality control program. Table 1 presents the current preliminary results of alpha and beta analyses. Strontium–90 results are presented quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 geographically presents the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. The radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process. A description of the sampling and analytical procedures was published in the December 1965 issue of RHD (*5*).

Complete data and exact sampling locations are published in annual compilations (*6–11*) or are available on request.

Summary

Comments on the data are being made when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. Changes toward or from these levels are discussed in terms of significant

Table 1. Radioactivity in raw surface waters, July 1965, preliminary data

(Average concentrations in pCi/liter)

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	14	5	19	5	0	5
Arkansas River:						
Ponca City, Okla	39	20	59	9	3	12
Atchafalaya River:						
Morgan City, La	57	16	73	32	1	33
Bear River:						
Preston, Idaho	2	30	32	0	1	1
Big Horn River:						
Hardin, Mont	33	12	45	9	3	12
Chena River:						
Fairbanks, Alaska	1	4	5	<1	1	1
Clearwater River:						
Lewiston, Idaho	2	3	5	<1	0	<1
Clinch River:						
Clinton, Tenn	1	3	4	0	0	0
Kingston, Tenn	1	36	37	0	0	0
Colorado River:						
Loma, Colo	25	10	35	6	3	9
Page, Ariz	<1	13	13	0	2	2
Parker Dam, Calif-Ariz	0	25	25	0	6	6
Columbia River:						
Wenatchee, Wash	1	6	7	0	0	0
Pasco, Wash	23	123	146	0	<1	<1
Clatskanie, Ore	16	54	70	<1	<1	<1
Connecticut River:						
Enfield Dam, Conn	2	7	9	0	0	0
Coosa River:						
Rome, Ga	1	4	5	0	0	0
Cumberland River:						
Cheatham Lock, Tenn	1	6	7	0	0	0
Delaware River:						
Philadelphia, Pa	1	8	9	0	0	0
Great Lakes:						
Duluth, Minn	0	6	6	0	0	0
Green River:						
Dutch John, Utah	25	19	44	3	4	7
Hudson River:						
Poughkeepsie, N.Y	0	8	8	0	0	0
Illinois River:						
Peoria, Ill	3	14	17	0	2	2
Kansas River:						
De Soto, Kans	94	18	112	35	2	37
Klamath River:						
Keno, Ore	1	14	15	0	<1	<1
Maumee River:						
Toledo, Ohio	1	11	12	0	0	0
Mississippi River:						
St. Paul, Minn	3	26	29	1	2	3
New Orleans, La	17	15	32	5	2	7
Missouri River:						
Williston, N. Dak	6	11	17	2	2	4
Bismarck, N. Dak	4	18	22	1	4	5
St. Joseph, Mo	93	18	111	36	3	39
Missouri City, Mo	246	16	262	70	1	71
North Platte River:						
Henry, Nebr	9	28	37	1	14	15
Ohio River:						
Toronto, Ohio	1	10	11	0	0	0
Cairo, Ill	2	8	10	1	0	1
Pend Oreille River:						
Albeni Falls Dam, Idaho	1	5	6	0	1	1
Platte River:						
Plattsmouth, Nebr	66	29	95	18	8	26
Potomac River:						
Washington, D.C	1	9	10	0	1	1
Rainy River:						
Baudette, Minn	1	19	20	0	0	0
Red River, North:						
Grand Forks, N. Dak	11	34	45	1	1	2
Red River, South:						
Alexandria, La	1	18	19	0	1	1
Rio Grande:						
El Paso, Tex	20	12	32	5	3	8
Laredo, Tex	5	18	23	1	2	3
San Joaquin River:						
Vernalis, Calif	7	14	21	1	7	8
San Juan River:						
Shiprock, N. Mex	122	12	134	38	3	41
Savannah River:						
Port Wentworth, Ga	4	11	15	<1	0	<1
Snake River:						
Payette, Idaho	1	11	12	0	5	5
Wawawai, Wash	1	4	5	0	1	1
South Platte River:						
Julesburg, Colo	13	53	66	2	36	38
Susquehanna River:						
Conowingo, Md	0	5	5	0	0	0
Tennessee River:						
Chattanooga, Tenn	1	6	7	0	0	0
Wabash River:						
New Harmony, Ind	13	11	24	3	1	4
Yellowstone River:						
Sidney, Mont	73	9	82	18	2	20
Maximum	246	123	262	70	36	71
Minimum	0	3	4	0	0	0

NS, no sample.

changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram for all stations of the Water Pollution Surveillance System will be attempted at this time.

The following stations showed alpha values on suspended or dissolved solids of 15 pCi/liter or more for both July and the previous month:

Kansas River, De Soto, Kans.
Missouri River, St. Joseph, Mo.
Platte River, Plattsmouth, Nebr.
South Platte River, Julesburg, Colo.
Yellowstone River, Sidney, Mont.

Each of the above stations showed reasonable values for alpha radioactivity per gram of suspended or dissolved solids. The high alpha values in pCi/liter merely reflect parallel high values for solids.

The following stations, which showed a gross alpha radioactivity in suspended or dissolved solids of 15 pCi/liter or more for the previous month, declined to values of less than 15 pCi/liter for July:

Arkansas River, Ponca City, Okla.
Big Horn River, Hardin, Mont.
Rio Grande, El Paso, Tex.
Rio Grande, Laredo, Tex.

These declines in radioactivity per liter merely reflect a decline in solids levels.

The following stations showed an increase in alpha values in suspended solids from June to July:

Atchafalaya River, Morgan City, La.
San Juan River, Shiprock, N. Mex.

This increase was due to a parallel increase in suspended solids.

The Missouri City station on the Missouri River showed high alpha and beta activities in

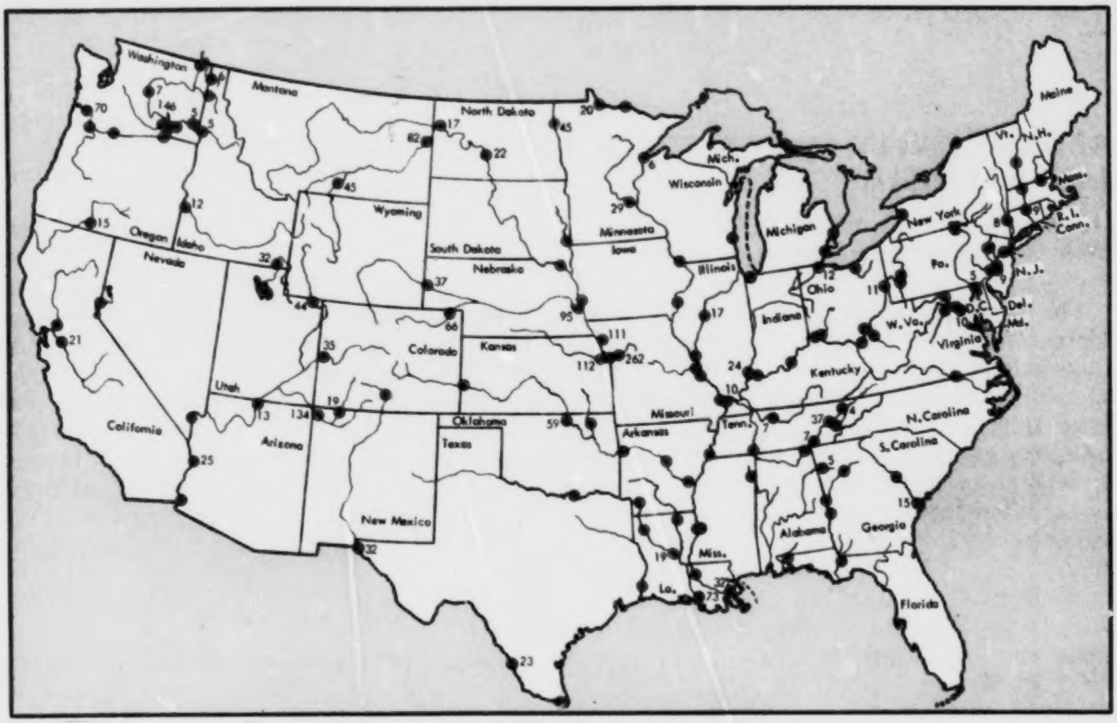
Washington
Montana
North Dakota
Minnesota
Wisconsin
Mich.
Michigan
Maine
Vt.
N.H.
Mass.
R.I.
Conn.
New York
Pa.
N.J.
Del.
Md.
D.C.
W. Va.
Virginia
Ohio
Indiana
Illinois
Iowa
Kentucky
Tenn.
N. Carolina
S. Carolina
Georgia
Alabama
Florida
Miss.
La.
Arkansas
Missouri
Oklahoma
Texas
Kansas
Nebraska
South Dakota
Wyoming
Colorado
New Mexico
Arizona
Utah
Nevada
California
Oregon
Idaho
70
7
146
5
5
15
12
62
17
22
45
45
20
6
29
32
37
66
64
35
21
95
111
112
262
17
24
10
12
11
8
9
5
10
13
134
19
59
25
32
23
19
32
73
7
37
4
5
15

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, July 1965

suspended solids. No sample was received for June. The July sample demonstrated reasonable radioactivity per gram of suspended solids. Consequently, these values also reflect high solids content.

The station on the Platte River at Plattsmouth, Nebraska, showed a decline in gross beta activity in suspended solids from 277 pCi/liter for June to 66 pCi/liter for July. This decline was due to a parallel decrease in suspended solids. Note that this decrease also affected the alpha activity.

Although the station on the Arkansas River at Coolidge, Kansas, showed a high alpha and beta radioactivity in dissolved solids for June, no sample was received for July. These high values, however, reflected only high solids contents.

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(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

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(*5*) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. Gross radioactivity in surface waters of the United States, June 1965. Rad Health Data 6:707–710 (December 1965).

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(*7*) *Ibid.*, 1959 Edition. Price $1.75.

(*8*) *Ibid.*, 1960 Edition.

(*9*) *Ibid.*, 1961 Edition.

(*10*) *Ibid.*, 1962 Edition.

(*11*) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. Water Pollution Surveillance System, annual compilation of data. PHS Publication No. 663 (revised) 1963 Edition.[2]

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[2] Single free copies of this publication may be obtained from: Public Inquires Branch. Pubilc Health Service, U.S. Department of Health, Education, and Welfare, Washington, D.C. 20201.

RADIOACTIVITY IN NEW YORK SURFACE WATER JANUARY-JUNE 1965

Division of Environmental Health Service
State of New York Department of Health

The New York Department of Health began a program in 1955 to determine the amount of radioactivity in water used for public consumption. This radioactivity in water may arise from any one or a combination of the following sources: the natural mineral content of water (background), atmospheric fallout, or nuclear industry operations. Water samples are obtained from 43 locations for gross beta analysis (figure 1). Table 1 gives the sampling frequency and type of sample. Larger size samples are collected at selected locations for strontium-90 analysis.

Analytical procedures

Beta activity concentrations are determined by evaporating a known volume of water to dryness and counting in an end-window, gas-flow proportional counter.

For strontium-89 and strontium-90 determinations, a measured volume of water is passed through an ion exchange column. The radiostrontium is complexed on the resin as strontium sulfate. The strontium is then eluted from the resin. The resultant solution is concentrated and subsequently counted in a low background, end-window, gas-flow proportional counter. Successive countings at 2-day intervals facilitate the determination of the strontium-90 and strontium-89 concentrations.

Discussion and results

The observed gross beta activity concentrations in New York surface water for January-June 1965 are given in table 1. It should be noted that the Cohoes gross beta results are for a raw water sample, while the Cohoes radiostrontium results are for a finished water.

The observed strontium-89 and strontium-90 concentrations in New York water for January through June 1965 are presented in table 2.

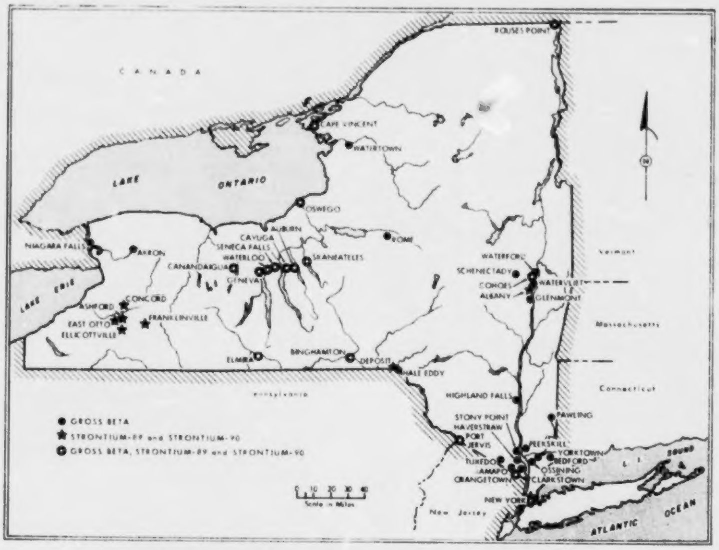
CANADA
LAKE ONTARIO
LAKE ERIE
ROUSES POINT
CAPE VINCENT
WATERTOWN
OSWEGO
ROME
AUBURN
CAYUGA
SENECA FALLS
WATERLOO
SKANEATELES
NIAGARA FALLS
AKRON
CANANDAIGUA
GENEVA
CONCORD
ASHFORD
EAST OTTO
FRANKLINVILLE
ELLICOTTVILLE
ELMIRA
BINGHAMTON
DEPOSIT
HALE EDDY
WATERFORD
SCHENECTADY
COHOES
ALBANY
WATERVLIET
GLENMONT
Vermont
Massachusetts
Connecticut
Pennsylvania
HIGHLAND FALLS
STONY POINT
HAVERSTRAW
PORT JERVIS
PAWLING
PEEKSKILL
YORKTOWN
BEDFORD
TUXEDO
RAMAPO
OSSINING
ORANGETOWN
CLARKSTOWN
NEW YORK
New Jersey
L. I. SOUND
ATLANTIC OCEAN
● GROSS BETA
★ STRONTIUM-89 and STRONTIUM-90
◎ GROSS BETA, STRONTIUM-89 and STRONTIUM-90
0 10 20 30 40
Scale in Miles

Figure 1. New York water sampling locations

Table 1. Gross beta activity concentrations in New York raw surface water January–June 1965

Location	Sampling	Concentration, pCi/liter					
		Jan	Feb	Mar	Apr	May	Jun
Akron (Murder Creek)	BD	9.5	9	10.5	9.5	8	NS
Auburn (Owasco Lake)	Q	NS	NS	6	NS	NS	NS
Bedford (Byram Lake)	M	6	6	8	12	4	NS
Binghamton (Binghamton Water Supply)	Q	NS	NS	6	NS	NS	NS
Canandaigua (Canandaigua Lake)	Q	NS	6	NS	NS	NS	NS
Cape Vincent (St. Lawrence River)	Q	NS	NS	7	NS	NS	NS
Cayuga (Cayuga Lake)	Q	NS	NS	5	NS	NS	NS
Clarkstown (Congers Lake)	Q	NS	NS	NS	NS	NS	13
(Lake De Forest)	M	NS	12	6	7	NS	7
Cohoes (Mohawk River)	D	5.3	7.8	5.8	10.2	6.3	NS
Elmira (Chemung River)	Q	NS	NS	3	NS	NS	NS
Geneva (Seneca Lake)	Q	5	NS	NS	NS	NS	NS
Glenmont (Hudson River)	D	5.6	8.3	5.8	6	6	NS
Hale Eddy (Delaware River)	Q	NS	NS	2	NS	NS	NS
Haverstraw (Letchworth River)	M	NS	2	2	3	NS	3
Highland Falls (Bog Meadow Brook)	M	3	3	3	3	2	NS
Lansing (Airport Well)	Q	NS	NS	NS	NS	NS	<1
(Bush Well)	Q	NS	NS	NS	NS	NS	1
(Neigh Well)	Q	NS	NS	NS	NS	NS	1
Niagara Falls (Niagara River)	M	NS	NS	8	9	NS	8
(Niagara River, West Branch)	M	NS	6	6	7	NS	7
Orangetown (Hackensack River)	Q	NS	NS	3	NS	NS	NS
Ossining (Hudson River)	D	32.3	29.5	23.4	27.5	14	23
(Indian Brook Reservoir)	M	8	9	8	7	4	NS
Oswego (Lake Ontario)	W	4.3	3.5	4.5	NS	6	6
(Oswego River)	Q	NS	NS	NS	9	NS	NS
Pawling (Pond At United Nuclear)	M	5	7	5	7	6	NS
Peekskill (Camp Field Water Supply)	M	NS	12	3	5	6	NS
(Hudson River)	D	32	20.5	12.2	18	7.3	15
Port Jervis (Delaware River)	Q	NS	4	NS	NS	NS	NS
Ramapo (Hillburn Reservoir)	BD	NS	NS	1	2	NS	3
Rome (Fish Creek)	BD	6	6	4.5	5	5	NS
Rouses Point (Lake Champlain)	Q	NS	NS	NS	NS	5	NS
Schenectady (Mohawk River)	C	5.8	5.4	5.3	5.5	4.5	NS
Seneca Falls (Cayuga Lake)	Q	NS	NS	5	NS	7	NS
Skaneateles (Skaneateles Lake)	Q	NS	NS	NS	5	NS	NS
Stony Point (Iona Island)	M	NS	2	2	NS	NS	NS
Tuxedo (Indian Kill)	M	9	7	5	5	5	NS
Waterford (Hudson River)	C	6	6.7	5.2	5.8	11.5	NS
Waterloo (Seneca River)	Q	NS	NS	7	NS	NS	NS
Watertown (Black River)	BD	5.5	8	5.5	6	8.5	NS
Watervliet (French Mills Reservoir)	BD	5	7	5	4	NS	NS
Yorktown (Croton Reservoir)	M	6	3	NS	NS	2	NS

Key to symbols: BD—Bi-weekly composite of daily grab samples.
D—Weekly composite of daily grab samples.
C—Continuous bleed-off-analyzed weekly.
W—Weekly grab sample.
M—Monthly grab sample.
Q—Quarterly grab sample.
NS—No sample collected.

Table 2. Strontium-89 and strontium-90 concentrations in New York water, January–June 1965

Sampling location	Strontium-89 concentration, pCi/liter						Strontium-90 concentration, pCi/liter					
	Jan	Feb	Mar	Apr	May	June	Jan	Feb	Mar	Apr	May	June
Albany (treated water)	<3	<3	<3	<3	<3	NS	<3	<3	4	<3	<3	NS
Ashford (Buttermilk & Frank Creek)	<3	NS	NS	<3	<3	<3	<3	NS	NS	<3	<3	4
(Hayes Hollow Bridge)	<3	NS	NS	NS	<3	<3	<3	NS	NS	NS	<3	<3
(Fox Valley Bridge)	<3	<3	<3	<3	<3	<3	<3	3	<3	<3	<3	<3
(Cattaraugus Creek at Bigelow Bridge)	<3	<3	<3	<3	NS	NS	<3	<3	<3	<3	NS	NS
(West Valley Water Supply)	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
Auburn	NS	NS	<3	NS	NS	NS	NS	NS	<4	NS	NS	NS
Binghamton	NS	NS	<3	NS	NS	<3	NS	NS	<3	NS	NS	<3
Canandaigua	NS	<3	NS	NS	NS	NS	NS	<3	NS	NS	NS	NS
Cape Vincent	NS	NS	<3	NS	NS	NS	NS	NS	<3	NS	NS	NS
Cayuga	NS	NS	<3	NS	NS	NS	NS	NS	<3	NS	NS	NS
Cohoes (treated water)	<3	<3	<3	<3	<3	NS	<3	<3	<4	<3	<3	NS
Concord (18 Mile Creek)	<3	NS	<3	NS	<3	NS	3	NS	<3	NS	<3	NS
Deposit	NS	NS	<3	NS	NS	NS	NS	NS	<3	NS	NS	NS
East Otto (East Otto Creek)	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
(Cattaraugus Creek at Scoby Hill Bridge)	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3	<3
(Connoisauraley Creek)	<3	<3	<3	<3	<3	<3	<3	<3	3	<3	<3	<3
Ellicottville	<3	<3	<3	<3	<3	NS	<3	<3	<3	<3	<3	NS
Elmira	NS	NS	<3	NS	NS	NS	NS	NS	<3	NS	NS	NS
Franklinville	<3	<3	<3	<3	<3	NS	<3	<3	<3	<3	<3	NS
Geneva	<3	<3	<3	<3	<3	NS	<3	<3	<3	<3	<3	NS
New York City (Ridgewood Reservoir)	<3	NS	NA	NS	NS	NS	<3	NS	NA	NS	NS	NS
(Jerome Park Reservoir)	<3	NS	<3	NS	<3	NS	3	NS	<3	NS	5	NS
(Central Park Reservoir)	NS	<3	NS	NS	NS	NS	NS	5	NS	NS	NS	NS
(Croton Water Supply)	NS	NS	NS	<3	NS	NS	NS	NS	NS	<3	NS	NS
Orangetown	NS	NS	<3	NS	NS	NS	NS	NS	<3	NS	NS	NS
Oswego (Lake Ontario)	NS	NS	NS	<3	NS	NS	NS	NS	NS	<3	NS	NS
(Oswego River)	NS	NS	NS	NS	NS	NS	NS	NS	NS	<3	NS	NS
Port Jervis	<3	NS	NS	NS	NS	NS	<3	NS	NS	NS	NS	NS
Rouses Point	NS	NS	NS	NS	<3	NS	NS	NS	NS	NS	<3	NS
Seneca Falls	NS	NS	<3	NS	<3	NS	NS	NS	<3	NS	<3	NS
Skaneateles	NS	NS	NS	<3	NS	NS	NS	NS	NS	<3	NS	NS
Waterloo	NS	NS	<3	NS	NS	NS	NS	NS	<3	NS	NS	NS

Key to symbols: NA, no analysis performed
NS, no sample collected

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Other State coverage:

Program	*Last presented*
California surface water sampling program	*September 1965*
Florida water sampling program	*November 1965*
Kentucky water sampling program	*March 1965*
Minnesota surface water sampling program	*August 1965*
New York surface water sampling program	*September 1965*
North Carolina water sampling program	*November 1965*
Washington surface water sampling program	*February 1965*

Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data do not provide enough information to assess total human radiation exposure from fallout, they can be used for determining when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercalibration of the above networks was performed by Lockhart (*1*) in 1962.

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1. Radiation Surveillance Network
September 1965

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, where they are analyzed for gross beta activity. Selected samples are also analyzed by gamma spectrometry. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to forwarding the samples. When high air levels are reported, appropriate officials are promptly notified. Compilation of daily field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analysis procedures was presented in the December 1965 issue of *Radiological Health Data*.

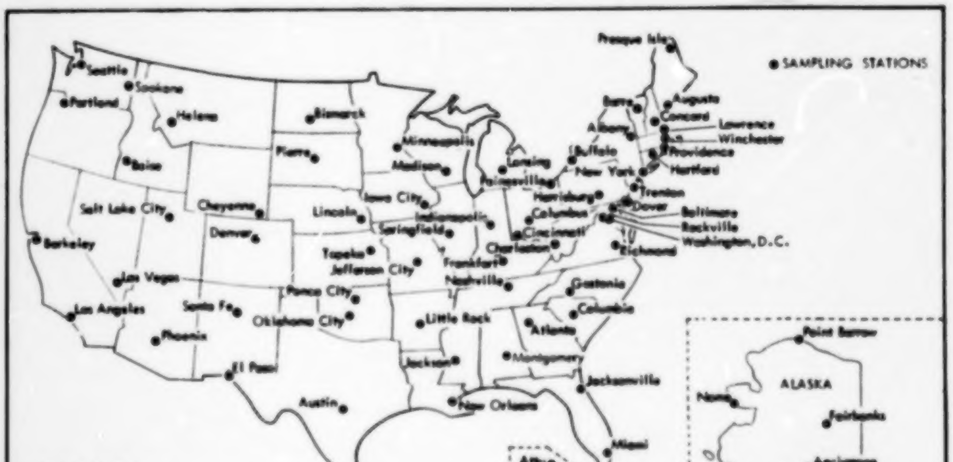
SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Boise
Bismarck
Pierre
Minneapolis
Madison
Lansing
Painesville
Buffalo
New York
Presque Isle
Barre
Augusta
Concord
Albany
Lawrence
Winchester
Providence
Hartford
Trenton
Harrisburg
Dover
Baltimore
Rockville
Washington, D.C.
Columbus
Cincinnati
Charleston
Richmond
Salt Lake City
Cheyenne
Lincoln
Iowa City
Indianapolis
Springfield
Denver
Berkeley
Topeka
Jefferson City
Frankfort
Nashville
Las Vegas
Gastonia
Columbia
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Little Rock
Atlanta
Phoenix
El Paso
Jackson
Montgomery
Jacksonville
Austin
New Orleans
Miami
ALASKA
Point Barrow
Nome
Fairbanks
Attu
Anchorage
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
Agana, Guam
Honolulu, Hawaii
San Juan, Puerto Rico
Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

Results

Monthly values of gross beta activity in air and precipitation are given in table 1 for September 1965. Activities remained at low levels. Of 300 air samples gamma scanned, none showed traces of fresh fission products. Time profiles of gross beta activity in air dating back to 1958 for eight RSN stations are shown in figure 2.

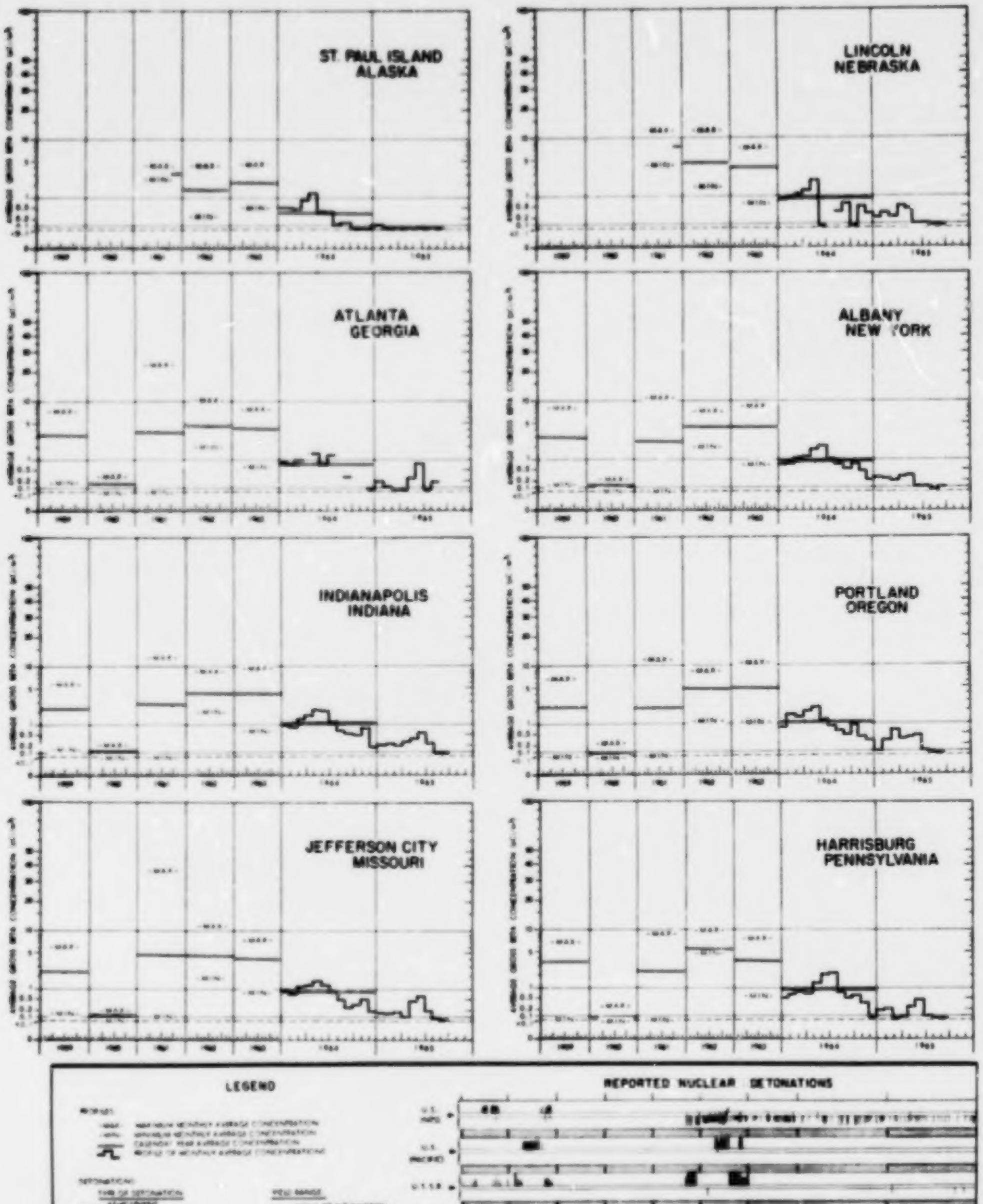

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1959—September 1965

Table 1. Gross beta activity in surface air and precipitation, September 1965

Station location		Air surveillance						Precipitation	
		Number of samples		Gross beta activity, pCi/m³			Last profile in *RHD*	Total depth (mm)	Total deposition (nCi/m²)
		Air	Ppt	Maximum	Minimum	Average [a]			
Ala:	Montgomery	30	5	.17	<.10	<.10	May 65	73	<15
Alaska:	Adak	29		.12	<.10	<.10	Sep 65	(b)	
	Anchorage	22	16	<.10	<.10	<.10	May 65	76	<15
	Attu Island	12		<.10	<.10	<.10	Oct 65	(b)	
	Fairbanks	11	4	<.10	<.10	<.10	Jun 65	26	<5
	Juneau	11	4	.16	<.10	<.10	Jul 65	44	<9
	Kodiak	6		<.10	<.10	<.10	Aug 65	(b)	
	Nome	6		<.10	<.10	<.10	Dec 65	(b)	
	Point Barrow	(c)					Nov 65	(b)	
	St. Paul Island	27		<.10	<.10	<.10	Jan 66	(c)	
Ariz:	Phoenix	28		.24	<.10	<.13	Jul 65	(b)	
Ark:	Little Rock	20	4	.16	<.10	<.11	Jun 65	152	<30
Calif:	Berkeley	20		.17	<.10	<.11	Aug 65	(b)	
	Los Angeles	30	6	.15	<.10	<.11	Dec 65	11	<2
C. Z:	Ancon	17		<.10	<.10	<.10	Aug 65	(b)	
Colo:	Denver	28	6	.28	<.10	<.12	Aug 65	77	<16
Conn:	Hartford	29	7	.12	<.10	<.10	Jul 65	64	<13
Del:	Dover	20		.16	<.10	<.11	May 65	(b)	
D. C:	Washington	29	6	.13	<.10	<.10	Nov 65	53	<11
Fla:	Jacksonville	30	10	.13	<.10	<.10	Jun 65	158	<32
	Miami	21	9	.17	<.10	<.11	Jul 65	106	<21
Ga:	Atlanta	(c)	5				Jan 66	72	<15
Guam:	Agana	29		.14	<.10	<.10	Apr 65	(b)	
Hawaii:	Honolulu	30	4	.15	<.10	<.10	Oct 65	70	<14
Idaho:	Boise	29	2	.18	<.10	<.11	Oct 65	4	<1
Ill:	Springfield	28	1	.13	<.10	<.10	Nov 65	6	<1
Ind:	Indianapolis	30	8	.12	<.10	<.10	Jan 66	129	<26
Iowa:	Iowa City	29	13	.11	<.10	<.10	Aug 63	246	<49
Kans:	Topeka	30	7	.13	<.10	<.10	May 65	140	<28
Ky:	Frankfort	29	8	.20	<.10	<.10	Nov 65	40	<8
La:	New Orleans	29	7	<.10	<.10	<.10	Nov 65	98	<20
Maine:	Augusta	30	7	.12	<.10	<.10	Dec 65	58	<12
	Presque Isle	21	7	<.10	<.10	<.10	Aug 65	93	<19
Md:	Baltimore	20	3	.15	<.10	<.11	Jul 65	26	<5
	Rockville Lab	16		.16	<.10	<.11	Oct 65	(b)	
Mass:	Lawrence	28	7	.16	<.10	<.11	May 65	129	<26
	Winchester	26	6	<.10	<.10	<.10	Sep 65	60	<12
Mich:	Lansing	30	10	.12	<.10	<.10	Oct 65	156	<31
Minn:	Minneapolis	22	9	.11	<.10	<.10	Apr 65	155	<31
Miss:	Jackson	29	5	.16	<.10	<.10	Dec 65	121	<24
Mo:	Jefferson City	30	8	.13	<.10	<.10	Jan 66	172	<35
Mont:	Helena	29	14	.20	<.10	<.11	Sep 65	94	<19
Nebr:	Lincoln	17	4	.15	<.10	<.11	Jan 66	128	<26
Nev:	Las Vegas	25		.22	<.10	<.13	Jun 65	(b)	
N. H:	Concord	20		.13	<.10	<.10	Nov 65	(b)	
N. J:	Trenton	27	3	.15	<.10	<.11	Dec 65	16	<3
N. Mex:	Santa Fe	28	8	.12	<.10	<.10	Sep 65	31	<7
N. Y:	Albany	21	11	.15	<.10	<.10	Jan 66	118	<23
	Buffalo	28		.13	<.10	<.10	Aug 65	(b)	
	New York	30		<.10	<.10	<.10	Sep 65	(b)	
N. C:	Gastonia	30	2	.16	<.10	<.11	Aug 65	17	<3
N. Dak:	Bismarck	25	12	.11	<.10	<.10	Nov 65	111	<23
Ohio:	Cincinnati	12		<.10	<.10	<.10	May 65	(b)	
	Columbus	30	7	.20	<.10	<.11	Dec 65	178	<36
	Painesville	29	8	.16	<.10	<.11	Jul 65	42	<9
Okla:	Oklahoma City	24	1	<.10	<.10	<.10	Oct 65	54	<11
	Ponca City	27	7	<.10	<.10	<.10	Jul 65	93	<19
Ore:	Portland	29	1	.27	<.10	<.16	Jan 66	1	<0
Pa:	Harrisburg	26	2	<.10	<.10	<.10	Jan 66	34	<7
P. R:	San Juan	7	4	<.10	<.10	<.10	Dec 65	34	<7
R. I:	Providence	28	5	<.10	<.10	<.10	Oct 65	42	<8
S. C:	Columbia	30	6	.13	<.10	<.10	Sep 65	146	<29
S. Dak:	Pierre	29	4	.14	<.10	<.10	Jul 65	33	<7
Tenn:	Nashville	29	7	<.10	<.10	<.10	Oct 65	59	<12
Tex:	Austin	30	8	.12	<.10	<.10	May 65	173	<35
	El Paso	28	4	.16	<.10	<.10	Nov 65	30	<6
Utah:	Salt Lake City	29	7	.29	<.10	<.13	Dec 65	60	<13
Vt:	Barre	29	7	.13	<.10	<.10	Jun 65	105	<21
Va:	Richmond	30	4	.13	<.10	<.10	Jun 65	123	<25
Wash:	Seattle	30	4	.12	<.10	<.10	May 65	18	<4
	Spokane	29	1	.14	<.10	<.10	Apr 65	2	<0
W. Va:	Charleston	29	7	.14	<.10	<.10	Sep 65	63	<13
Wisc:	Madison	30	12	<.10	<.10	<.10	Jun 65	205	<41
Wyo:	Cheyenne	30	9	.15	<.10	<.11	Jun 65	34	<8
Network summary		1,818	363	0.29	<0.10	<0.10		82	<16

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[a] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.

[b] Indicates no precipitation sample collected.

[c] Indicates no report received.

2. Canadian Air and Precipitation Monitoring Program September 1965 [1]

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data.*

Surface air and precipitation data for September 1965 are presented in table 2. Specific radionuclide data are presented in table 3.

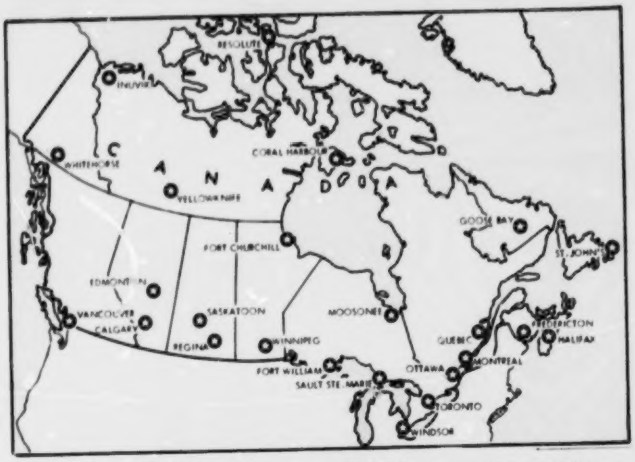

Figure 3. Canadian air and precipitation sampling stations

Table 2. Canadian gross beta activity in surface air and precipitation, September 1965

Station	Air surveillance				Precipitation measurements	
	Number of samples	Activity, pCi/m³			Average concentration (pCi/liter)	Total deposition (nCi/m²)
		Maximum	Minimum	Average		
Calgary	30	0.2	0.0	0.1	45	3.7
Coral Harbour	30	0.2	0.0	0.0	20	1.0
Edmonton	30	0.1	0.0	0.1	96	2.2
Ft. Churchill	28	0.1	0.0	0.0	32	1.5
Ft. William	30	0.1	0.0	0.1	33	5.4
Fredericton	30	0.1	0.0	0.1	45	1.7
Goose Bay	30	0.1	0.0	0.1	41	2.9
Halifax	30	0.1	0.0	0.1	52	1.5
Inuvik	30	0.2	0.0	0.0	67	1.4
Montreal	29	0.1	0.0	0.1	27	2.8
Moosonee	30	0.1	0.0	0.0	35	2.9
Ottawa	29	0.2	0.0	0.1	43	2.9
Quebec	30	0.1	0.0	0.1	19	2.9
Regina	30	0.2	0.0	0.1	45	2.5
Resolute	28	0.1	0.0	0.0	NS	NS
St. John's, Nfld	28	0.2	0.0	0.1	26	1.6
Saskatoon	24	0.1	0.0	0.1	55	1.7
Sault Ste. Marie	30	0.1	0.0	0.0	18	3.4
Toronto	30	0.1	0.0	0.1	27	1.7
Vancouver	30	0.2	0.0	0.1	120	1.8
Whitehorse	30	0.2	0.0	0.1	26	0.8
Windsor	29	0.2	0.0	0.1	23	1.3
Winnipeg	30	0.1	0.0	0.1	45	2.9
Yellowknife	30	0.1	0.0	0.0	309	1.0
Network summary	—	0.1	0.0	0.1	54	2.2

NS, no sample collected.

Table 3. Radionuclide deposition in Canadian fallout, September 1965[a] (nCi/m²)

Station	Strontium-90	Cesium-137
Calgary	0.22	0.38
Coral Harbour	0.05	0.08
Edmonton	0.17	0.22
Ft. Churchill	0.18	0.27
Ft. William	0.52	0.74
Fredericton	0.22	0.27
Goose Bay	0.73	0.20
Halifax	0.16	0.21
Inuvik	0.14	0.18
Montreal	0.18	0.31
Moosonee	0.24	0.45
Ottawa	0.19	0.34
Quebec	0.26	0.37
Regina	0.11	0.38
Resolute	NS	NS
St. John's, Nfld	0.19	0.27
Saskatoon	0.16	0.38
Sault Ste. Marie	0.34	0.40
Toronto	0.11	0.17
Vancouver	0.15	0.26
Whitehorse	0.05	0.09
Windsor	0.13	0.20
Winnipeg	0.19	[illegible]
Yellowknife	0.15	[illegible]
Average	0.21	[illegible]

NS, no sample collected.
[a] ^{89}Sr, ^{95}Zr, and ^{140}Ba not reported due to insignificantly low levels.

3. Mexican Air Monitoring Program
September 1965

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico is operated by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961, an earlier network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*8–12*).

The new Radiation Surveillance Network, operated by CNEN's Division of Radiological Protection, consists of 17 stations (see figure 4), 12 of which are located at airports and operated by airline personnel. The remaining five stations are operated by staff members of other agencies.

Sampling procedures were outlined in the December 1965 issue of *Radiological Health Data*.

Table 4 presents the maximum, minimum, and average gross beta activity concentrations in surface air during September 1965.

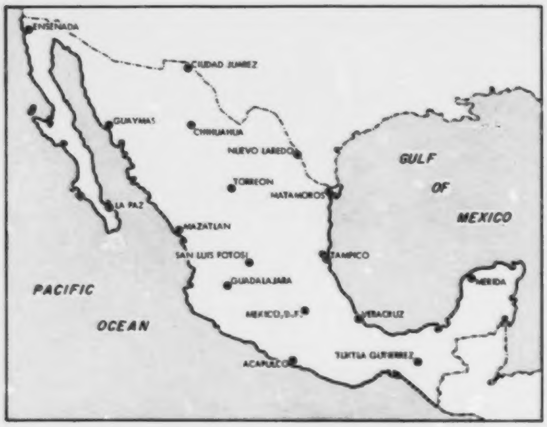

Figure 4. Mexican air monitoring sampling locations

Table 4. Mexican gross beta activity of airborne particulates, September 1965

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco	17	0.1	<0.1	<0.1
Ciudad Juárez	18	0.1	<0.1	<0.1
Chihuahua	20	0.2	<0.1	0.1
Enseñada	9	0.2	<0.1	0.1
Guadalajara	14	<0.1	<0.1	<0.1
Guaymas	12	<0.1	<0.1	<0.1
La Paz	8	0.2	<0.1	<0.1
Matamoros[a]				
Mazatlán	16	0.1	<0.1	<0.1
Mérida	10	0.1	<0.1	<0.1
México, D.F.	17	0.1	<0.1	<0.1
Nuevo Laredo	5	0.1	<0.1	<0.1
San Luis Potosí	15	0.1	<0.1	<0.1
Tampico	19	0.2	<0.1	<0.1
Torréon	20	0.2	<0.1	<0.1
Tuxtla Gutiérrez[a]				
Veracruz	10	<0.1	<0.1	<0.1

[a] Temporarily shut down.

4. Pan American Air Sampling Program
September 1965

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by several countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization (PAHO) and the Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The September 1965 air monitoring results from the participating countries are given in table 5. Sampling station locations are shown in figure 5.

Table 5. Gross beta activity in surface air (concentrations in pCi/m³), September 1965

Station location	Number of samples	Maximum	Minimum	Average[a]
Buenos Aires, Argentina	7	<0.10	<0.10	<0.10
Santiago, Chile	27	0.11	<0.10	<0.10
Kingston, Jamaica	10	<0.10	<0.10	<0.10
Lima, Peru	7	<0.10	<0.10	<0.10
Caracas, Venezuela	21	<0.10	<0.10	<0.10
Trinidad, West Indies	20	<0.10	<0.10	<0.10
Summary	92	0.11	<0.10	<0.10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.

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[1] Prepared from information and data in the October 1965 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

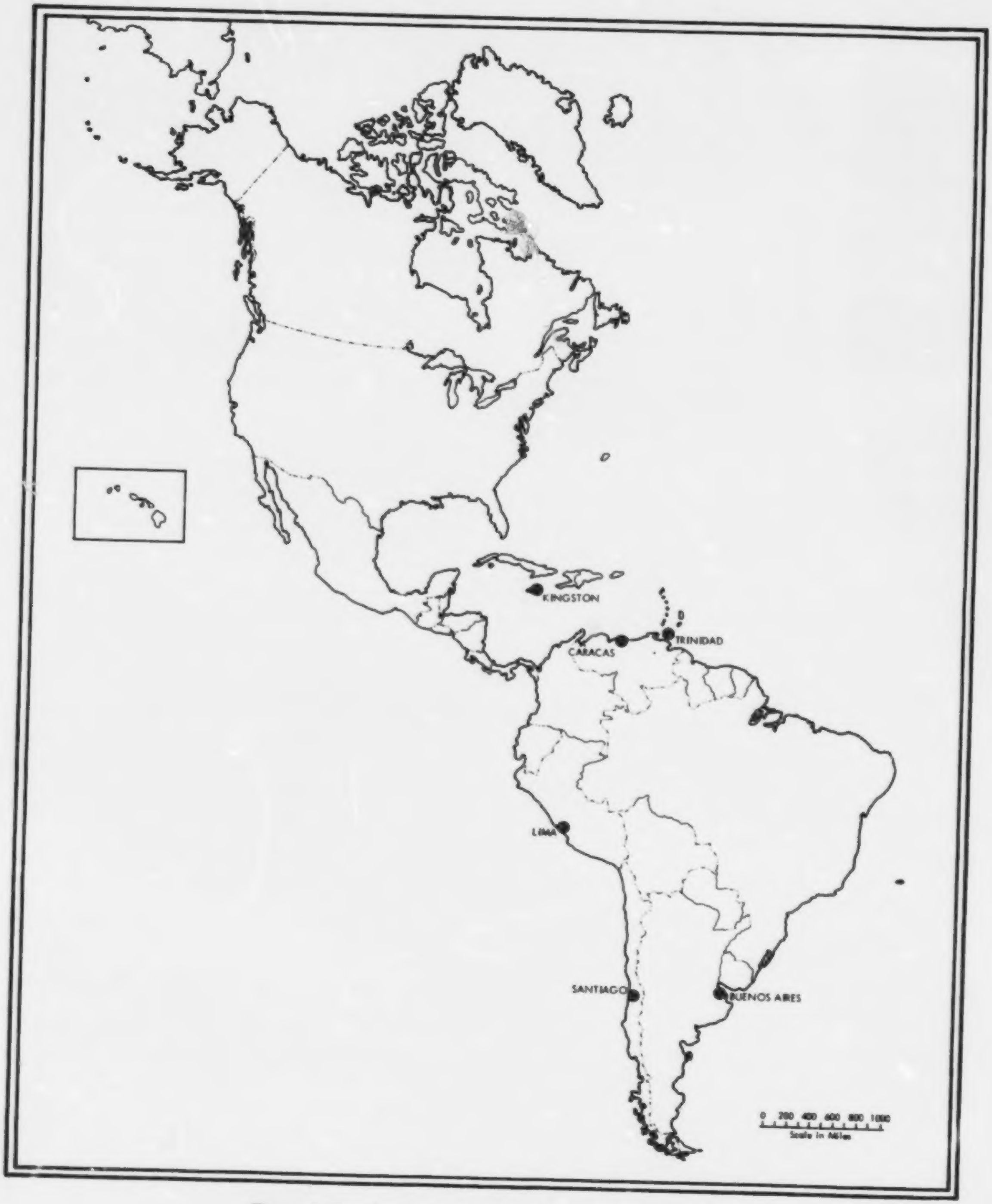
KINGSTON
TRINIDAD
CARACAS
LIMA
SANTIAGO
BUENOS AIRES
0 200 400 600 800 1000
Scale in Miles

Figure 5. Pan American Air Network sampling stations

5. National Air Sampling Network July–September 1965

Division of Air Pollution
Public Health Service

The necessity of having basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. One of the many analyses performed by the NASN on their air samples is for gross beta radioactivity. NASN stations (figure 5) are manned by cooperating Federal, State, and local agencies. The network consists of 110 sampling stations which operate every year and 130 stations which operate every other year. A description of the sampling network was presented in the December 1965 issue of *Radiological Health Data*. Third quarter 1965 gross beta activities in air are given in table 6.

Previous coverage in *Radiological Health Data:*

Period	*Issue*
Annual Summary 1964	*April 1965*
January–March 1965	*July 1965*
April–June 1965	*October 1965*

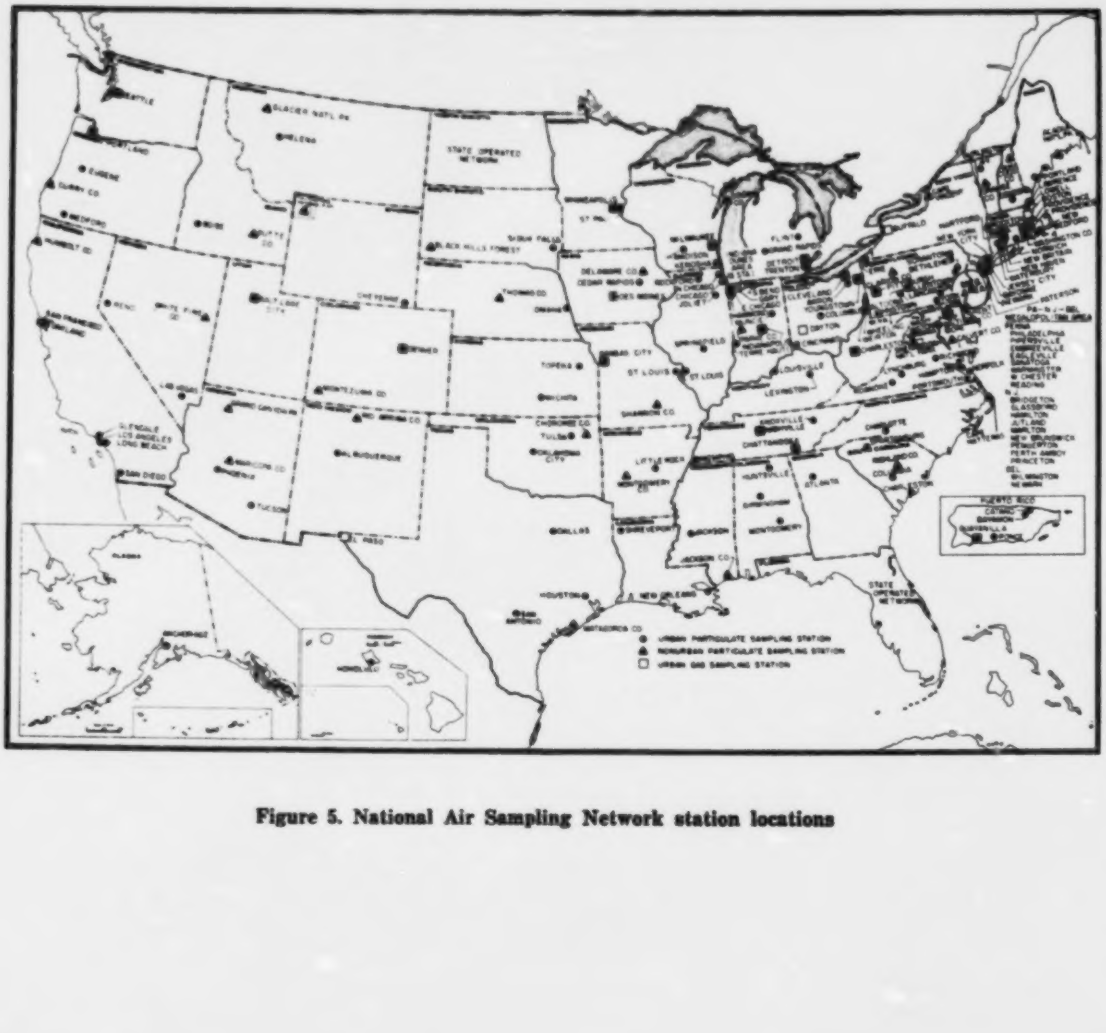
STATE OPERATED NETWORK
STATE OPERATED NETWORK
PUERTO RICO
● URBAN PARTICULATE SAMPLING STATION
▲ NONURBAN PARTICULATE SAMPLING STATION
☐ URBAN GAS SAMPLING STATION

Figure 5. National Air Sampling Network station locations

Table 6. Gross beta activity in surface air, NASN, July–September 1965

Station name		Number of samples	Maximum	Minimum	Average
			(pCi/m³)	(pCi/m³)	(pCi/m³)
Ala:	Birmingham	6	0.4	0.1	0.2
	Huntsville	7	0.5	<0.1	0.2
	Montgomery	6	0.2	<0.1	0.1
Ariz:	Grand Canyon Park •	6	0.4	0.1	0.2
	Paradise Valley	7	0.4	0.1	0.2
	Phoenix	7	0.4	<0.1	0.2
	Tucson	5	0.3	0.1	0.1
Ark:	Little Rock	6	0.4	0.1	0.2
	Montgomery County •	4	0.3	0.1	0.2
Calif:	Glendale	7	0.2	0.1	0.2
	Humboldt County •	6	0.1	0.1	0.1
	Long Beach	6	0.2	0.1	0.2
	Los Angeles	5	0.2	0.1	0.2
	Oakland	6	0.2	0.1	0.1
	San Diego	7	0.2	0.1	0.2
	San Francisco	7	0.2	0.1	0.1
Colo:	Denver	6	0.9	0.2	0.4
	Montezuma County •	5	0.4	<0.1	0.2
Conn:	Hartford	6	0.9	<0.1	0.3
	New Britain	7	0.9	0.1	0.3
	New Haven	5	0.9	<0.1	0.3
	Norwich	5	0.9	0.1	0.4
	Waterbury	7	1.0	0.1	0.3
Dela:	Kent County •	5	1.0	0.1	0.4
	Newark	6	0.4	<0.1	0.3
	Wilmington	5	0.4	0.1	0.2
D. C:	Washington	7	0.6	0.1	0.3
Ga:	Atlanta	6	0.3	<0.1	0.2
Hawaii:	Honolulu	6	0.2	0.1	0.1
Idaho:	Boise	6	0.9	0.1	0.4
	Butte County •	6	0.4	0.2	0.3
Ill:	Chicago	6	0.5	0.1	0.2
	East St. Louis	6	0.7	0.1	0.4
	Joliet	5	0.6	0.1	0.3
	North Chicago	4	0.4	0.2	0.3
	Rockford	7	0.7	0.1	0.3
	Springfield	6	0.5	0.1	0.3
Ind:	East Chicago	6	0.5	0.1	0.3
	Hammond	6	0.5	0.1	0.3
	Indianapolis	7	0.6	0.1	0.3
	Parke County •	6	0.3	0.1	0.2
	Portage	4	0.5	<0.1	0.2
	Beverly Shores	7	0.5	0.1	0.2
	Dunes Police Post #1	5	0.5	0.1	0.3
	Dunes State Park	5	0.2	0.1	0.1
	Ogden Dunes	5	0.3	0.1	0.2
	South Bend	5	0.5	0.1	0.3
	Terre Haute	3	0.4	0.1	0.2
Iowa:	Cedar Rapids	7	0.8	0.1	0.3
	Delaware County •	6	0.3	0.1	0.2
	Des Moines	6	0.7	0.1	0.3
Kans:	Topeka	6	0.4	0.1	0.2
	Wichita	7	0.4	0.1	0.2
Ky:	Lexington	7	0.4	0.1	0.2
	Louisville	6	0.5	0.1	0.2
La:	New Orleans	6	0.3	<0.1	0.2
	Shreveport	7	0.3	0.1	0.2
Maine:	Acadia Nat Park •	4	0.2	0.1	0.1
	Portland	6	0.3	0.1	0.2
Md:	Baltimore	7	0.9	<0.1	0.3
	Calvert County •	7	0.3	0.1	0.2
Mass:	Brockton	5	0.2	0.1	0.2
	Lawrence	6	0.5	0.1	0.2
	Lowell	3	0.2	0.1	0.2
	New Bedford	3	1.4	0.1	0.5
Mich:	Detroit	5	0.4	0.1	0.2
	Flint	6	0.3	0.1	0.2
	Grand Rapids	5	0.4	0.1	0.2
	Trenton	7	0.7	0.1	0.2
Minn:	Minneapolis	6	0.7	0.1	0.3
	St. Paul	7	0.6	0.1	0.3
Miss:	Jackson	6	0.4	0.1	0.2
	Jackson •	6	0.2	<0.1	0.1
Mo:	Kansas City	6	0.3	0.1	0.2
	St. Louis	6	0.5	0.1	0.2
	Shannon County •	6	0.4	0.1	0.2
Mont:	Glacier Nat Park •	5	0.6	0.1	0.2
	Helena	5	0.4	<0.1	0.2
Nebr:	Omaha	7	0.7	0.1	0.3
	Thomas County •	7	0.6	<0.1	0.2
Nev:	Las Vegas	7	0.8	0.1	0.3
	Reno	7	0.4	0.1	0.2
	White Pine County	5	0.2	0.1	0.2
N. H:	Concord	7	0.9	0.1	0.3
	Coos County •	5	0.9	0.1	0.3
N. J:	Bayonne	3	0.7	0.2	0.4
	Bridgeton	6	0.4	<0.1	0.3
N. J.—Continued					
	Pemberton	7	1.0	0.1	0.3
	Marlton	5	0.4	<0.1	0.2
	Glassboro	6	1.0	<0.1	0.3
	Hamilton	6	0.3	<0.1	0.2
	Jutland	4	0.6	0.1	0.3
	Jersey City	7	0.4	<0.1	0.2
	Newark	6	0.9	<0.1	0.3
	Paterson	6	0.7	<0.1	0.3
	Perth Amboy	7	1.0	<0.1	0.4
	Princeton	5	0.4	0.2	0.2
N. Mex:	Albuquerque	6	0.3	0.1	0.2
	Rio Arriba County	7	0.3	<0.1	0.1
N. Y:	Cape Vincent •	6	1.0	0.1	0.3
	New York City	6	1.1	<0.1	0.4
N. C:	Charlotte	7	0.6	0.1	0.2
	Cape Hatteras •	7	0.3	0.1	0.2
Ohio:	Akron	6	0.6	0.1	0.3
	Cincinnati	7	0.4	0.1	0.2
	Cleveland	7	0.5	0.1	0.3
	Columbus	6	0.7	0.1	0.3
	Toledo	7	0.5	<0.1	0.3
	Youngstown	7	0.7	<0.1	0.3
Okla:	Cherokee County •	7	0.4	0.1	0.2
	Oklahoma City	7	0.3	0.1	0.2
	Tulsa	6	0.3	0.1	0.2
Ore:	Curry County •	5	0.1	<0.1	0.1
	Eugene	7	0.4	0.1	0.2
	Medford	6	0.4	0.1	0.2
	Portland	7	0.3	0.1	0.2
Penna:	Allentown	4	0.2	0.1	0.2
	Altoona	5	1.1	0.1	0.5
	Bethlehem	5	0.4	<0.1	0.2
	Pipersville	5	0.9	0.1	0.3
	Embreeville	6	0.9	0.1	0.3
	Clarion County •	6	0.7	<0.1	0.2
	Erie	6	0.7	0.1	0.3
	Johnstown	6	0.7	<0.1	0.3
	Lancaster	6	1.0	<0.1	0.4
	Eagleville	4	0.8	0.1	0.3
	Sanatoga	4	0.3	<0.1	0.2
	Philadelphia	6	0.4	<0.1	0.3
	Pittsburgh	5	0.3	<0.1	0.1
	Reading	5	1.0	<0.1	0.3
	Warminster	6	0.3	0.1	0.2
	West Chester	7	0.8	<0.1	0.3
	York	7	1.0	<0.1	0.3
P. R:	Bayamon	5	0.1	<0.1	0.1
	Guayanilla	6	0.2	<0.1	0.1
	Ponce	7	0.2	0.1	0.1
	San Juan	6	0.3	<0.1	0.1
R. I:	East Providence	5	0.3	0.1	0.2
	Providence	7	0.9	0.1	0.3
	Washington County •	7	1.0	0.1	0.4
S. C:	Charleston	5	0.2	0.1	0.2
	Richland County •	3	0.1	<0.1	0.1
	Spartanburg	7	0.7	0.1	0.2
S. Dak:	Black Hills Forest •	7	0.3	<0.1	0.1
	Sioux Falls	7	0.8	<0.1	0.2
Tenn:	Chattanooga	5	0.2	<0.1	0.1
	Knoxville	6	0.4	<0.1	0.2
	Memphis	7	0.4	<0.1	0.2
	Nashville	5	0.4	0.1	0.2
Tex:	Dallas	7	0.3	0.1	0.2
	Houston	6	0.3	0.1	0.2
	Matagorda County •	6	0.2	<0.1	0.1
	San Antonio	7	0.3	<0.1	0.1
Utah:	Salt Lake City	7	0.7	0.1	0.2
Vt:	Burlington	6	0.9	<0.1	0.3
	Orange County •	6	0.8	0.1	0.3
Va:	Hampton	6	0.8	0.1	0.3
	Lynchburg	7	0.3	0.1	0.2
	Norfolk	6	0.9	0.1	0.3
	Shenandoah Nat Park	7	0.7	<0.1	0.3
	Portsmouth	7	0.8	0.1	0.3
	Richmond	6	1.3	<0.1	0.4
	Roanoke	6	0.8	<0.1	0.3
Wash:	Seattle	7	0.1	<0.1	0.1
W. Va:	Charleston	6	0.3	0.1	0.2
	Weirton	5	0.7	0.1	0.3
	Wheeling	7	0.6	<0.1	0.3
Wis:	Door County •	4	0.2	0.2	0.2
	Kenosha	6	0.7	0.1	0.3
	Madison	6	0.7	0.1	0.3
	Milwaukee	6	0.3	0.1	0.2
Wyo:	Cheyenne	6	0.6	0.1	0.3
	Yellowstone Park •	6	1.0	<0.1	0.3

• Denotes nonurban station.

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Other Air and Deposition Networks previously covered:

Network	*Period*	*Issue*
HASL Fallout	April–December 1964	*September 1965*
Canadian Fallout	October–December 1964	*September 1965*

Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such typical data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Oak Ridge Area, Paducah Plant, and the Portsmouth Area Gaseous Diffusion Plant.

Radioactive waste materials arising from the operation of atomic energy installations in the Oak Ridge Area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ion exchange activity that enables it to fix radioactive materials. Liquid wastes which contain long-lived fission products are confined in storage tanks or are released to trenches located in the Conasauga shale formation. Low-level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

1. Oak Ridge Area[2]
January–June 1965

Union Carbide Nuclear Company
Oak Ridge, Tennessee

Oak Ridge Area is a complex made up primarily of the Y–12 Plant, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Air monitoring

Atmospheric contamination by long-lived fission products and fallout occurring in the general environment of East Tennessee is monitored by two systems of monitoring stations. One system consists of eight stations which encircle the plant areas (figure 1) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of seven stations encircling the Oak Ridge Area at distances of from 12 to 75 miles (figure 2). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur.

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[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

[2] Summarized from Environmental Levels of Radioactivity for the Oak Ridge Area, compiled by the Applied Health Physics Section of the Health Physics Division, Oak Ridge National Laboratory.

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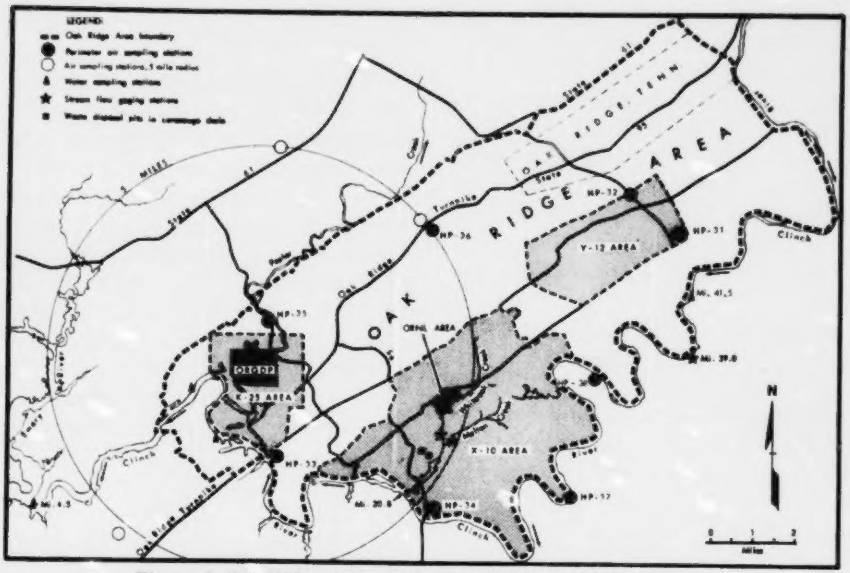
LEGEND:
Oak Ridge Area boundary
Perimeter air sampling stations
Air sampling stations, 5 mile radius
Water sampling stations
Stream flow gaging stations
5 MILES
State 61
OAK RIDGE, TENN
OAK RIDGE AREA
Turnpike
HP-32
HP-31
HP-36
HP-35
HP-33
HP-34
HP-37
Y-12 AREA
ORNL AREA
X-10 AREA
ORGDP
K-25 AREA
Clinch
River
Oak Ridge Turnpike
Mi. 41.5
Mi. 39.0
Mi. 20.8
Mi. 4.5
N
0 1 2
Miles

Figure 1. Oak Ridge Area environmental sampling locations

Sampling for radioactive particulates is carried out by passing air continuously through a filter paper. Average concentrations are presented in table 1. Airborne radioactive iodine is monitored in the immediate environment of the plant areas by passing air through a cartridge containing activated charcoal.

Table 1. Long-lived gross beta concentrations in air, Oak Ridge Area, average concentrations in pCi/m^3

Perimeter stations (see figure 1)	Number of samples	First half 1965	Remote stations (see figure 1)	Number of samples	First half 1965
HP-31	26	0.26	HP-51	26	0.33
HP-32	26	0.29	HP-52	26	0.24
HP-33	26	0.23	HP-53	26	0.29
HP-34	26	0.26	HP-54	26	0.29
HP-35	26	0.29	HP-55	25	0.29
HP-36	182	0.31	HP-56	25	0.27
HP-37	26	0.25	HP-57	26	0.28
HP-38	26	0.33			
Average		0.28	Average		0.28

Atmospheric contamination by alpha emitting materials, interpreted as uranium, is determined by gross alpha measurements of continuous 8-hour air samples taken at three locations on a 5-mile radius from the ORGDP (figure 1). The data are summarized in table 2.

Table 2. Long-lived gross alpha activity in air[a] five miles from ORGDP, average concentrations in pCi/m^3

Direction from plant	First half 1965
North	0.6
Northeast	0.8
Southwest	0.9

[a] Interpreted as uranium (natural).

Milk monitoring

Raw milk is monitored for iodine–131 and strontium–90 by the collection and analysis of samples from 12 sampling stations located within a radius of 50 miles of ORNL. Samples are collected weekly at each of eight stations located on the fringe of the Oak Ridge Area. Four stations, located more remotely with respect to Oak Ridge operations, are sampled at a rate of one station each week. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of the Oak Ridge Area provide data by which one may evaluate possible exposure to the neighboring population resulting from waste releases from Oak Ridge operations; second, samples collected at the more remote stations provide background data which are essential in establishing the proper index for the evaluation of data obtained from local samples.

Water monitoring

Large volume, low-level liquid wastes originating at ORNL are discharged, after some preliminary treatment, into the Tennessee River System by way of White Oak Creek and Clinch River. Liquid wastes originating at the ORGDP and Y–12 Plant are discharged to Poplar Creek and thence to the Clinch River. The radioactivity concentration from White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry, near Kingston, Tennessee. Stream gauging operations are carried on continuously by the U.S. Geological Survey to obtain dilution factors for calculating the probable concentrations of wastes in the river.

Samples are analyzed for the long-lived beta emitters, uranium, and the transuranic alpha emitters.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and holdup time in the waste effluent system are such that no short-lived radionuclides are present. The averages are given in table 3. No uranium was detected in Clinch River water samples during this period.

Table 3. Concentrations of major radionuclides in the Clinch River, average concentrations in pCi/liter

Radionuclide	First half 1965		
	Location on Clinch River [a]		
	Mile 41.5 (Upstream)	Mile 20.8 [b] (Outfall)	Mile 4.5 (Downstream)
^{90}Sr	0.8	1.3	1.6
^{144}Ce	0.3	<0.1	0.4
^{137}Cs	<0.1	0.4	2.5
^{106}Ru	1.6	15	17
^{60}Co	[c] ND	2.5	2.7
^{95}Zr-^{95}Nb	ND	<0.1	0.2
Gross beta	2.7	44	24

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River. See figure 1.

[b] The concentrations at mi. 20.8 are not measured directly but the values are calculated on the basis of levels of waste released and the dilution afforded by the river.

[c] ND indicates none was detected.

Gamma measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge Area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above ground, and the results are shown in table 4 in terms of mR/hr.

Table 4. External gamma radiation levels, Oak Ridge area, average dose rates in mR/hr

Location	First half 1965
Solway Gate	0.014
Y-12 East Portal	0.011
Newcomb Road	0.011
Gallaher Gate	0.012
White Wing Gate	0.011
Average	0.012

Discussion of data

The average air contamination level for gross beta activity, as shown by the continuous air monitoring filter data, for both the immediate and remote environs of the plant (figure 1 and 2) was 0.28 percent of the maximum permissible concentration for populations in the neighborhood of a controlled area. This value is approximately 30 percent lower than those for the last half of 1964 and is no higher than the average of those measured in other areas of the United States and reported by the U.S. Public Health Service Radiation Surveillance Network for the period January through April 1965.

The average concentration of iodine-131 in air in the immediate environs of the plant was 0.022 pCi/m^3. This is approximately 0.022 percent of the maximum permissible concentration for populations in the neighborhood of a controlled area.

The average airborne alpha activity in the environs of the ORGDP, five miles from ORGDP, was 4.0 percent of the maximum permissible concentration for populations in the neighborhood of a controlled area.

The average concentrations of iodine-131 in raw milk in the immediate and remote environs of the Oak Ridge Area were 8.7 pCi/liter and 5.4 pCi/liter, respectively. These values fall within the limits of FRC Range I if one assumes the average intake per individual to be 1 liter of milk per day. The maximum concentration observed in any one milk sample was 75 pCi/liter. This value was measured in a sample collected the week of May 30 through June 5, 1965. During this time the East Tennessee Area was experiencing an increase in fallout from weapons testing. Laboratory analyses of samples of fallout confirmed the presence of fresh fission products consistent with the timing of the announced nuclear detonation on the Chinese mainland, May 14, 1965.[3]

The average concentration of strontium-90 in raw milk for both the immediate and remote environs of the controlled area was 17 pCi/liter. This level falls within FRC Range I for transient rates of daily intake of strontium-90 for application to the average of suitable samples of an exposed population.

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[3] Radiological Health Data, Vol. 6, No. 6, p. 332 (June 1965).

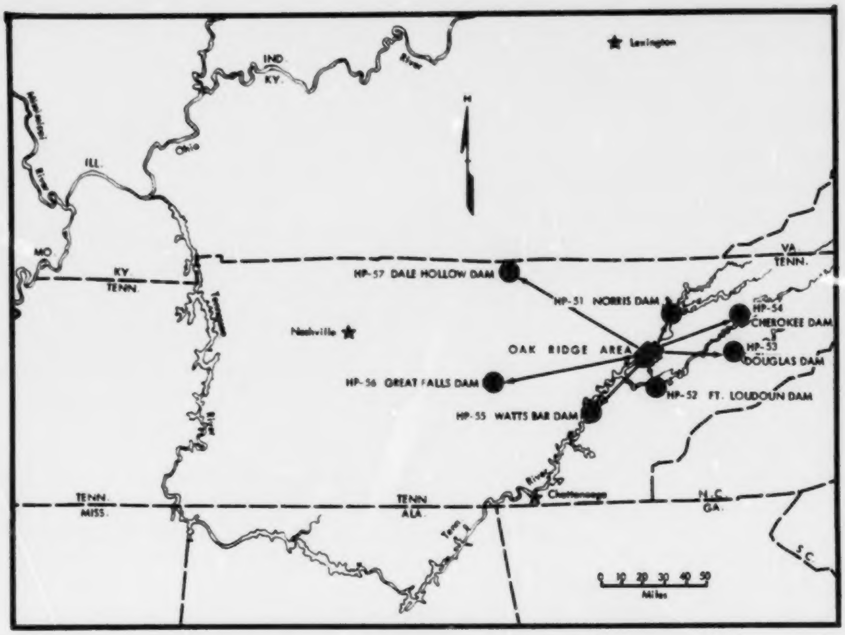
Lexington
IND.
KY.
River
Ohio
Mississippi
River
ILL.
MO.
KY.
TENN.
N
VA.
TENN.
HP-57 DALE HOLLOW DAM
HP-51 NORRIS DAM
HP-54
CHEROKEE DAM
Nashville
OAK RIDGE AREA
HP-53
DOUGLAS DAM
HP-56 GREAT FALLS DAM
HP-52 FT. LOUDOUN DAM
HP-55 WATTS BAR DAM
Tennessee
River
River
Chattanooga
TENN.
MISS.
TENN.
ALA.
Tenn. R.
N.C.
GA.
S.C.
0 10 20 30 40 50
Miles

Figure 2. Remote air monitoring stations, Oak Ridge Area

The calculated average concentration of radioactivity in the Clinch River at Mile 20.8 (the point of entry of most of the wastes) and the measured average concentration at Mile 4.5 (near Kingston, Tennessee) were 44 pCi/liter and 28 pCi/liter, respectively. These values are 0.86 percent and 0.73 percent of the weighted average maximum permissible concentrations $(MPC)_w$. The average concentration of transuranic alpha emitters in the Clinch River at Mile 20.8 was 0.1 pCi/liter which is approximately 0.002 percent of the weighted average $(MPC)_w$ value.

The average activity of natural uranium materials in the Clinch River, reflecting the effects of all Oak Ridge plants, was <0.01 percent of the $(MPC)_w$ for uranium.

The average external gamma radiation measured in the town of Oak Ridge and at the perimeter of the Oak Ridge Area was 0.012 mR/hr, which is the same as that level measured in the early period prior to Oak Ridge operations.

Conclusion

Surveillance of the radioactivity in the Oak Ridge environs indicated that the major part of the radioactivity detected continues to be the result of fallout from weapons testing. While some low level radioactivity is being released to the environment from plant operations, the resulting concentrations in both the atmosphere and surface streams of the Oak Ridge environment are well below established maximum permissible concentrations and intake guides for the neighboring population.

Previous coverage in *Radiological Health Data:*

Period	Issue
First and second quarters 1961	*January 1962*
Third and fourth quarters 1961	*September 1962*
1962	*September 1963*
1963	*July 1964*
January–June 1964	*January 1965*
July–December 1964	*July 1965*

2. Paducah Plant
January–June 1965

Union Carbide Nuclear Company
Paducah, Kentucky

The Paducah Plant is a Government-owned gaseous diffusion plant operated by the Nuclear Division of the Union Carbide Corporation for the Atomic Energy Commission. The diffusion plant, with the associated uranium hexafluoride manufacturing plant and uranium metal foundry, processes large quantities of relatively pure uranium compounds. The major sources of external penetrating radiation are the daughter products of uranium, thorium–234, and protactinium–234, which may be concentrated by uranium recovery processes or by uranium hexafluoride vaporization. The element uranium can be a physiological hazard only if allowed to enter the body. The chemical toxicity of the uranium processed at the Paducah Plant overshadows any probable biological effects of radiation from this element, thus making it comparable as a physiological hazard to lead, mercury, or other well-known heavy metals.

Uranium is a rather expensive element, and this provides a great incentive to recover as much in any situation as is feasible. The added desire to maintain a wholesome relationship with neighboring communities and individuals makes it essential that entrained dust be filtered from exhaust systems, and that all effluent waters be maintained at extremely low concentrations of uranium.

Since no recovery process or filtering system is 100 percent efficient, an environmental monitoring program is required to evaluate the effectiveness of such measures. The Paducah Plant environmental monitoring program provides for continuously sampling air at four stations around the plant perimeter fence, and at five stations located approximately 1 mile outside this fence (figure 3). Big Bayou Creek water is sampled continuously, and grab samples are collected at five locations in the Ohio River. In addition, gamma radiation readings are taken each month at each of the air-sampling stations, with a Geiger-Mueller type meter, at a distance of 3 feet above ground level.

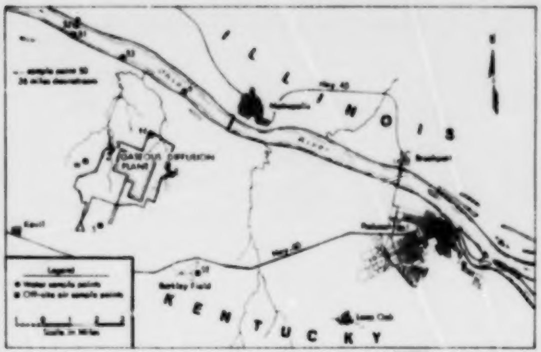

Figure 3. Water sampling locations, Paducah Plant

Basic standards

The standards observed at the Paducah Plant for exposure to radiation and radioactive materials, both for the in-plant work environment of employees and for offsite exposure of the general population, are those listed in the AEC manual (see footnote 2).

The standards specify that the radiation or radioactive materials outside a controlled area, and which have resulted from operations within the controlled area, shall be such that it is improbable that any individual may receive a dose of external radiation greater than 0.5 rem in any year and that the average exposure of a suitable population sample may not exceed one-

Table 5. Outdoor uranium air samples, Paducah Plant January–June 1965

Sample location [a]	Number of samples	Uranium alpha, [b] pCi/m³			Mean as percent of concentration limit [d]
		Maximum	Minimum [c]	Mean	
At plant perimeter fence					
N	26	0.24	<0.02	0.064	3
E	26	0.16	<0.02	0.035	2
S	26	0.23	<0.02	0.032	2
W	26	0.16	<0.02	0.036	2
Summary	104	0.24	<0.02	0.042	2
About one mile outside plant perimeter fence					
N	26	0.10	<0.02	0.032	2
E	26	0.15	<0.02	0.032	2
S	26	0.15	<0.02	0.036	2
W	26	0.21	<0.02	0.032	2
SE	26	0.18	<0.02	0.036	2
Summary	130	0.21	<0.02	0.034	2

[a] See map in figure 3.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57 x 10⁴ alpha dis/sec.
[c] The minimum detectable concentration of uranium in air is 0.02 μCi/m³.
[d] The concentration limit for natural uranium in air released to the environs is 2 pCi/m³.

Table 6. Outdoor beta air samples, Paducah Plant January–June 1965

Sample location [a]	Number of samples	Beta, pCi/m³			Mean as percent of concentration limit [c]
		Maximum	Minimum [b]	Mean	
At plant perimeter fence					
N	26	1.8	0.2	0.60	0.06
E	26	1.0	0.1	0.44	0.04
S	26	0.8	0.1	0.35	0.04
W	26	1.0	<0.1	0.43	0.04
Summary	104	1.8	<0.1	0.45	0.05
About one mile outside plant perimeter fence					
N	26	1.1	0.15	0.42	0.04
E	26	0.9	0.11	0.36	0.04
S	26	1.1	0.16	0.41	0.04
W	26	1.1	0.13	0.41	0.04
SE	26	0.9	0.20	0.42	0.04
Summary	130	1.1	0.11	0.40	0.04

[a] See map in figure 3.
[b] The minimum detectable amount of beta emitters in air is 0.1 pCi/m³.
[c] The concentration limit applicable to this table is 1,000 pCi/m³, which is the concentration limit of thorium-234, the daughter product of uranium-238. Insignificant amounts of other daughters are present in freshly refined uranium.

third of this dose. To meet this standard, the average concentration of radioisotopes in air or water beyond a controlled area should not exceed one-tenth of the maximum permitted for occupational exposure of 168 hours per week. For the purposes of such control, the concentrations of such radionuclides in air or water may be averaged over periods of time up to 1 year.

Discussion of data

Data summarizing the environmental concentrations of radioactive materials in air and water and the gamma radiation levels in the vicinity of the Paducah Gaseous Diffusion Plant are presented in tables 5 through 8.

Table 7. Concentration of uranium in water, Paducah Plant, January–June 1965

Sample location [a]	Number of samples	Uranium,[b] pCi/liter			Mean as percent of concentration limit [d]
		Maximum	Minimum [c]	Mean	
Big Bayou Creek 3	26	22	<1	7	0.04
Ohio River 9	6	1	<1	<1	<0.01
Composite of 50, 51, 52, & 53	6	2	<1	<1	<0.01

[a] See map in figure 3.
[b] As defined in NBS Handbook 69, paragraph 3.2, a microcurie of recently extracted normal uranium corresponds to 7.57×10^4 dis/sec.
[c] The minimum detectable uranium in water is 1 pCi/liter.
[d] The concentration limit for natural uranium in water beyond a controlled area is 20,000 pCi/liter.

Air samples are collected continuously at each of the four stations at the plant perimeter fence and at five stations at about 1 mile outside the plant. Air is filtered at 0.3 cfm through 2-inch diameter membrane filters which are replaced weekly and counted for alpha and beta activity.

Table 8. Concentration of beta emitters in water Paducah Plant, January–June 1965

Sample location [a]	Number of samples	Beta emitters, pCi/liter			Mean as percent of concentration limit [c]
		Maximum	Minimum [b]	Mean	
Big Bayou Creek 3	26	2,200	<100	210	1
Ohio River 9	6	700	<100	170	0.9
Composite of 50, 51, 52 & 53	6	100	<100	<100	<0.5

[a] See map in figure 3.
[b] The minimum detectable amount of beta emitters in water is 100 pCi/liter.
[c] The concentration limit for the daughter products of uranium in water released to the environs is 20,000 pCi/liter.

The average alpha count—interpreted as uranium, the most likely source of activity—of the 234 air samples collected during the first half of 1965 was 1.9 percent of the concentration limit for people residing in the vicinity of a controlled area. The mean beta counts of the same samples were 0.04 percent of the concentration limit.

The average of uranium analyses of weekly water samples collected by a continuous water sampler in the Big Bayou was 0.4 percent of the concentration limit for water beyond a controlled area. Six grab samples were collected each month from the Ohio River, below the plant. The uranium analyses for these samples showed concentrations less than 0.01 percent of the concentration limit. The average of beta analyses for the samples from the Big Bayou was 1 percent of the concentration limit for the decay products of uranium-238 in water beyond controlled area. The average of the beta analysis for all samples of Ohio River water was <3 percent of the concentration limit when interpreted as uranium daughters.

External gamma radiation in the vicinity of the Paducah Plant averaged 0.02 mR/hour at all sampling stations.

Previous coverage in *Radiological Health Data:*

Period	Issue
January–June 1961	*January 1962*
July–December 1961	*August 1962*
1962	*September 1963*
1963	*July 1964*
January–June 1964	*February 1965*
1964	*July 1965*

3. Portsmouth Area Gaseous Diffusion Plant[3]
January-June 1965

Goodyear Atomic Corporation
Piketon, Ohio

The separation of uranium isotopes by the gaseous diffusion process presents control problems similar to any chemical process using toxic solvents and extraction solutions. Natural uranium and thorium-234 are the most likely radionuclides to be released to the environment by the Portsmouth Area Gaseous Diffusion Plant. Since natural uranium is an alpha emitter and thorium-234 is a beta-gamma emitter, environmental monitoring is conducted for evidence of alpha and beta-gamma emitters to test the effectiveness of plant controls.

Continuous air samples are collected monthly at 21 sites located from 1 to 6 miles from the plant as shown in figure 4. Monthly water samples are collected at 13 stations within 5 miles of the plant.

For the first half of 1965, the average concentrations for both alpha and beta-gamma activity in the neighboring streams, creeks, and rivers, are above previously reported values. The overall averages and maximum values in off-plant waters, however, are well within permissible concentrations. For alpha activities, the average and maximum concentrations were 0.19 percent and 2.98 percent of the concentration limits, respectively, and for beta-gamma activities the average and maximum concentration values were 0.49 percent and 18 percent of the concentration limits, respectively.

The average airborne alpha activity also showed an increase compared with the past averages, while the beta-gamma airborne activity declined. The average airborne alpha activity was 16.1 percent of the concentration limit as compared to the usual 5 percent. In March and April, increases were noted and appeared to result from operating difficulties in a production area where uranium products had been released to the atmosphere during the reporting period. Two of the samples were in excess of the concentration limit for off-site locations.

Background radiation rates decreased by 36 percent from the previous 6-month period. As in the past, the onsite and offsite results are similar in trends with no appreciable difference between the two average values; therefore, it is concluded that the background counting rates are due to causes other than plant operations such as natural background and fallout from past nuclear detonations.

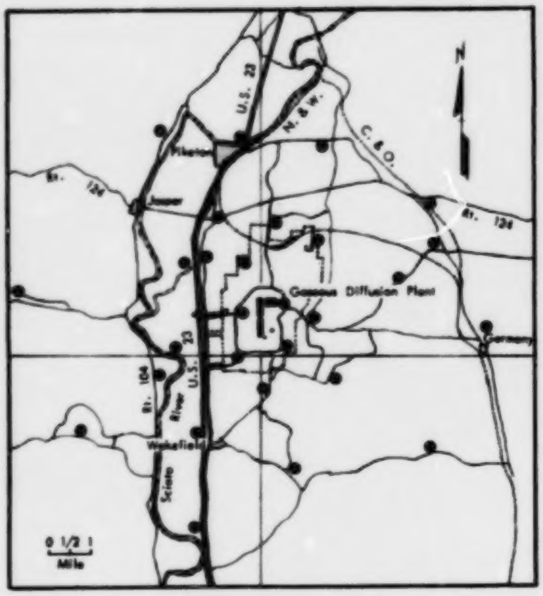

Figure 4. Air sampling locations, Portsmouth Area Gaseous Diffusion Plant

Average alpha and beta-gamma concentrations in air and water are summarized in table 9. The external gamma levels, measured at the air sampling locations shown in figure 4, are also summarized in table 9. The overall average

Table 9. Environmental radioactivity, Portsmouth Plant

Measurement	Unit	January-June 1965				
		No. of samples	Maximum	Minimum	Average	Average as percent of concentration limit[a]
Air (alpha concentration)	pCi/m³	126	4.6	<0.1	0.3	16.1
Air (beta-gamma concentration)	pCi/m³	126	4.7	<0.1	0.5	0.05
Water (alpha concentration)	pCi/liter	74	586	<0.5	37.6	0.19
Water (beta-gamma concentration)	pCi/liter	73	3,600	<14.0	98.8	0.49
External beta-gamma[b]	mrad/hr	126	0.05	0.01	0.03	30

[a] The applicable concentration or exposure limits are as follows:

Air (alpha)	2 pCi/m³
Air (beta-gamma)	1,000 pCi/m³
Water (alpha)	20,000 pCi/liter
Water (beta-gamma)	20,000 pCi/liter
External beta-gamma	500 mrad/yr (approx. 0.06 mrad/hr)

[b] Measurements were made with an open shield Geiger-Mueller tube one foot above ground. The 3-foot rate (not shown) was experimentally determined to average two-thirds of the 1-foot rate and was used to determine the percent of the concentration limit.

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[3] Data summarized from B. Kalmon: Environmental radiation levels and concentrations, first half 1965, GAT 505 (July 19, 1965).

concentrations and background radiation rates for January–June 1965 are presented in table 10, along with the values for the corresponding period in 1964, the second half of 1964, and the calendar year 1964.

Previous coverage in *Radiological Health Data:*

Period	Issue
First and second quatrers 1961	*February 1962*
Third and fourth quarters 1961	*September 1962*
1962	*May 1963*
1963	*July 1964*
1964	*July 1965*

Table 10. Comparison of average concentrations, Portsmouth Plant

Measurement	First half 1964	Second half 1964	Calendar 1964	First half 1965
	Percent of concentration or exposure limit [a]	Percent of concentration or exposure limit [a]	Percent of concentration or exposure limit [a]	Percent of concentration or exposure limit [a]
Water (alpha concentration)	0.06	0.07	0.07	0.19
Water (beta-gamma concentration)	<0.07	<0.07	<0.07	0.49
Air (alpha concentration)	5.0	5.50	5.0	16.1
Air (beta-gamma concentration)	0.23	0.08	0.15	0.05
Overall background exposure, extrapolated to 3 feet above ground (mrad)	47	47	48	30

[a] The applicable concentration or exposure limits are as follows:

Air (alpha)	2 pCi/m^3
Air (beta-gamma)	1,000 pCi/m^3
Water (alpha)	20,000 pCi/liter
Water (beta-gamma)	20,000 pCi/liter
External beta-gamma	500 mrad/yr (approx. 0.06 mrad/hr)

IODINE-131 IN BOVINE THYROIDS, JANUARY-JUNE 1965

Division of Radiological Health
Public Health Service

To supplement its existing environmental radiation surveillance systems, the Division of Radiological Health in October 1964 established a Bovine Thyroid Network (*1*). Specimens are collected by the Meat Inspection Division, U.S. Department of Agriculture, and analyzed for iodine–131 content at the Northeastern Radiological Health Laboratory, Winchester, Massachusetts.[1]

Details of sampling and analysis have been published earlier (*1*). Data for January through June 1965 appear in table 1 (page 48). The influx of fallout iodine–131 following the mainland China atmospheric nuclear detonation of May 14, 1965, was clearly evident in samples collected in June 1965. A discussion of bovine thyroid results in relation to other environmental sampling results following the second Chinese test appeared earlier (*2*).

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(*1*) BARATTA, E. J., E. R. WILLIAMS, and G. MURRAY. Iodine–131 in bovine thyroids, October–December 1964. Rad Health Data 6:573–578 (October 1965).

(*2*) DIVISION OF RADIOLOGICAL HEALTH, PHS. Detection of fresh fission product material in environmental samples following the second nuclear detonation on the Chinese Mainland. Rad Health Data 6:587–589 (October 1965).

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[1] The samples are analyzed under the direction of Mr. E. J. Baratta.

Table 1. Iodine-131 in bovine thyroids, January–June 1965

State and county of origin	Date of slaughter (1965)	Number of samples	Age in years	pCi iodine-131/g thyroid		
				Average	Minimum	Maximum
Ariz:						
Unknown	2/18	2	Unknown	[a] ND		
Maricopa	5/6	1	1	ND		
Calif:						
Fresno	1/6	1	4	ND		
Fresno	1/8	1	4	ND		
Solano	1/11	1	4	ND		
Merced	1/13	2	4–5	ND		
San Joaquin		1	4	ND		
Solano		1	4	ND		
San Bernardino	1/19	2	6–7	<1	ND	[a]1.1 ±0.9
Merced	2/1	1	5	ND		
Monterey	2/9	1	5	ND		
Monterey	2/15	2	8–9	ND		
Merced	2/16	2	7–8	ND		
Sacramento	2/17	2	9–10	ND		
Los Angeles	2/18	2	6	ND		
Stanislaus		1	6	ND		
Los Angeles	2/19	2	6–8	ND		
Los Angeles	2/23	1	5	ND		
San Bernardino		1	6	ND		
San Joaquin		2	5–6	ND		
Santa Barbara		1	5	ND		
Monterey	2/24	2	7	ND		
Fresno	2/25	2	6–7	ND		
Los Angeles		4	5–6	ND		
San Joaquin	2/26	3	5–7	ND		
Madera	3/1	1	6	ND		
Tulare		1	7	ND		
Marin	3/2	1	5	ND		
Riverside	3/2	2	6	ND		
Santa Cruz		2	5–6	ND		
Solano		1	7	ND		
Los Angeles	3/3	9	4–5	ND		
Shasta		1	6	ND		
Stanislaus		1	5	ND		
Unknown [b]	3/4	2	5	ND		
Los Angeles		1	4	ND		
Madera		1	2	ND		
San Joaquin		1	6	ND		
Los Angeles	3/5	2	5	ND		
Monterey		2	6–7	ND		
Los Angeles	3/8	2	5–6	ND		
Madera		2	6–7	ND		
Tulare		2	6	ND		
Fresno	3/9	2	6–7	ND		
Los Angeles		1	8	ND		
San Bernardino		1	5	ND		
Los Angeles	3/10	1	4	ND		
Orange		2	5	ND		
San Bernardino		1	5	ND		
San Joaquin		2	7–8	ND		
Tulare		2	4–6	ND		
Merced	3/11	2	8	<1	ND	1.4 ±0.8
San Benito	3/12	2	8	ND		
Los Angeles	3/15	2	7	ND		
Monterey		2	5–7	ND		
Los Angeles	3/16	1	5	ND		
Riverside		2	5–6	ND		
San Benito		1	7	ND		
Los Angeles	3/17	1	4	ND		
San Joaquin		1	7	ND		
Fresno	3/18	2	5–8	ND		
Los Angeles		1	3	ND		
San Joaquin	3/19	1	7	ND		
Riverside	3/22	2	6–8	ND		
Tulare		2	7	ND		
Los Angeles	3/24	1	3	ND		
Monterey		2	8–9	ND		
Merced	3/25	2	5–6	ND		
Orange		1	5	ND		
Tulare		2	10–11	<1	ND	1.3 ±0.9
Fresno	3/26	2	8–10	ND		
Los Angeles		2	4	ND		
Sacramento	3/29	3	7–8	ND		
Los Angeles	3/30	3	5–7	ND		
Merced		1	8	ND		
Riverside		2	6	ND		
San Bernardino	3/31	10	6	ND		
San Joaquin		2	8	ND		
San Joaquin	4/1	1	7	ND		
Sutter		1	6	ND		
Los Angeles	4/2	2	6–8	ND		
San Joaquin		2	6–7	ND		
Sonoma		2	3–5	ND		
Fresno	4/5	2	6	ND		
Tulare		1	7	ND		
Fresno	4/6	2	7	ND		
Los Angeles	4/7	1	5	ND		
Merced		2	8	ND		
San Bernardino		10	6	ND		

See footnotes at end of table, p. 53.

Table 1. Iodine-131 in bovine thyroids, January–June 1965—Continued

State and county of origin	Date of slaughter (1965)	Number of samples	Age in years	pCi iodine-131/g thyroid		
				Average	Minimum	Maximum
Calif—Continued						
Fresno	4/8	2	6–11	ND		
Los Angeles		1	7	ND		
Merced		1	8	ND		
San Benito		1	3	<1		
Los Angeles	4/9	1	7	ND		
Sacramento		1	3	ND		
San Joaquin		1	6	ND		
Monterey	4/12	2	9–10	ND		
Mariposa	4/13	2	8	ND		
Tulare		2	4–11	ND		
Fresno	4/14	2	10–11	ND		
Merced	4/15	2	5	ND		
Riverside	4/16	2	5	ND		
Monterey	4/19	2	10–11	1.4	1.2±1.0	1.5±1.3
Los Angeles	4/20	3	2–8	<1	ND	<1
San Benito		2	8–9	ND		
Los Angeles	4/21	2	Unknown	ND		
Sacramento		2	7–8	1.2	1.0±0.9	1.3±1.0
Fresno	4/22	2	7	1.0	ND	1.9±0.9
Los Angeles		10	6	>1	ND	1.4±0.9
Madera	4/23	2	5	ND		
Fresno	4/26	2	8	2.2	1.4±1.2	3.1±1.6
Los Angeles	4/27	2	7–8	ND		
Monterey		2	9–10	ND		
Santa Barbara		1	8	1.4±1.0		
Los Angeles	4/29	1	Unknown	ND		
Riverside		1	5	1.1±0.9		
San Bernardino		1	9	2.0±1.0		
San Joaquin		2	4–5	1.4	1.3±0.9	1.5±1.1
Fresno	4/30	2	6–7	2.0	1.6±1.2	2.3±1.4
San Bernardino		1	3	1.5±0.8		
Los Angeles	5/3	2	7	ND		
Merced		2	4–5	<1	ND	1.3±1.1
San Joaquin	5/4	2	8–9	1.8	1.5±0.8	2.1±1.1
Monterey	5/5	1	5	2.0±1.1		
San Joaquin		1	8	1.0±0.7		
Imperial	5/6	1	2	ND		
Los Angeles		2	7	<1	ND	<1
Merced		1	2	2.2±1.0		
Stanislaus		2	1–11	1.2	1.1±0.7	1.4±0.7
San Joaquin	5/7	1	4	ND		
Santa Clara		1	4	1.2±0.8		
Stanislaus	5/8	1	5	1.4±1.0		
Fresno	5/10	1	3	3.0±1.4		
Merced		1	5	ND		
Merced	5/11	1	5	ND		
San Joaquin		1	9	1.5±1.2		
Los Angeles	5/12	1	6	ND		
San Joaquin		2	4	1.7	1.5±1.0	1.9±1.4
Los Angeles	5/13	2	7–8	1.5	ND	2.9±1.1
Sacramento		1	4	ND		
San Bernardino		1	6	1.0±0.7		
San Joaquin		1	6	2.3±1.4		
Tulare		2	5	<1	ND	1.5±1.0
San Joaquin	5/14	2	6–8	ND		
Madera	5/17	2	6–7	ND		
Los Angeles	5/18	1	6	ND		
San Joaquin		2	6	ND		
Los Angeles	5/19	1	5	ND		
San Benito		2	6	1.0	ND	2.0±1.0
Tulare	5/20	2	6	3.5	3.0±1.0	4.0±1.0
Fresno	5/21	2	10–11	<1	ND	<1
Fresno	5/24	1	10	ND		
Los Angeles		1	4	ND		
Stanislaus		1	8	ND		
Los Angeles	5/25	3	5–8	ND		
Orange		10	6	<1	ND	2.0±1.0
San Joaquin		1	12	41±3.0		
San Luis Obispo		1	9	29±2.0		
Los Angeles	5/26	1	5	ND		
Riverside		1	3	ND		
San Joaquin		1	8	ND		
Stanislaus		1	11	4.0±2.0		
Imperial	5/27	1	3	ND		
Los Angeles		4	4–7	ND		
Tulare		2	20	50	42±1.0	58±1.0
Riverside	6/1	1	4	ND		
San Benito		2	7	12	10±1.0	14±1.0
Fresno	6/2	2	9–10	ND		
Los Angeles		3	5–8	6.0	ND	18±1.0
Los Angeles	6/3	1	5	2.0±1.0		
San Joaquin		4	5–8	62	3.0±1.0	175±2.0
Fresno	6/4	2	8–9	112	107±2.0	116±2.0
Imperial		2	3	1.0	ND	2.0±1.0
Merced		2	9–10	70	67±1.0	74±1.0
San Bernardino		1	8	ND		
Fresno	6/7	2	8	30	16±1.0	45±2.0
Madera	6/8	2	6	32	15±1.0	48±2.0
Los Angeles	6/9	3	6–7	ND		
Madera		1	8	33±1.0		
Riverside	6/9	1	8	ND		
Santa Barbara		2	4–6	ND		

See footnotes at end of table, p. 53.

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Table 1. Iodine-131 in bovine thyroids, January–June 1965—Continued

State and county of origin	Date of slaughter (1965)	Number of samples	Age in years	pCi iodine-131/g thyroid		
				Average	Minimum	Maximum
Calif—Continued						
Tulare	6/10	4	4-8	49	ND	141±2.0
Merced	6/14	2	8	80	27±2.0	134±2.0
Monterey		2	7	22	4.0±1.0	39±2.0
Imperial	6/15	2	3	ND		
Madera		2	7	83	78±2.0	88±3.0
Marin		2	5	8.5	6.0±1.0	11±1.0
San Joaquin		2	6	118	101±4.0	136±2.0
Orange	6/16	1	5	ND		
San Bernardino		1	6	ND		
San Joaquin		2	6	5.0	4.0±1.0	6.0±1.0
Los Angeles	6/17	2	5-6	53	7.0±1.0	99±2.0
San Benito		1	7	ND		
San Luis Obispo	6/21	1	5	ND		
San Joaquin		1	5	32±2.0		
Stanislaus		2	8	25	17±2.0	33±2.0
Los Angeles	6/22	3	6-8	ND		
Monterey		2	8-9	52	36±2.0	68±2.0
Riverside		1	7	ND		
San Benito		1	7	18±2.0		
San Joaquin		2	6	10	9.0±2.0	12±1.0
Los Angeles	6/23	1	5	ND		
Sacramento		1	3	ND		
Los Angeles	6/25	2	3-4	13	12±2.0	14±1.0
Merced		1	4	3.0±1.0		
Tulare		1	20	19±1.0		
Los Angeles	6/28	2	5-6	5.5	2.0±1.0	9.0±1.0
Merced		6	5-10	4.0	ND	13±2.0
Monterey		1	7	48±3.0		
Los Angeles	6/29	1	7	ND		
Orange		1	6	6.0±1.0		
Riverside		1	8	ND		
San Bernardino		1	4	5.0±1.0		
San Joaquin	6/30	2	9	9.0	7.0±3.0	11±1.0
Colo:						
Weld	1/20	1	8	ND		
Jefferson	1/22	1	10	ND		
Morgan		1	8	ND		
Montezuma	1/25	1	6	ND		
Montezuma	1/26	1	6	1.4±0.9		
Montezuma	1/27	1	9	ND		
Morgan		4	6-9	<1	ND	1.4±0.7
Montezuma	1/28	1	6	ND		
Morgan	2/8	1	6	ND		
Morgan	2/9	1	7	ND		
LaPlata	2/19	1	3	ND		
Conejos	4/21	4	7-8	<1	ND	1.9±0.9
Weld	4/22	2	6	1.0	ND	2.0±1.1
Morgan	4/23	1	old range cow	2.3±1.7		
Weld		1	old range cow	23±1.1		
LaPlata	4/26	4	9-11	<1	ND	2.1±1.2
Yuma	4/29	4	2	1.2	ND	2.5±1.7
Logan	4/30	1	5	<1		
Weld	5/7	1	Unknown	ND		
Weld	5/10	1	4	ND		
Adams	5/12	1	5	1.8±1.0		
LaPlata		1	4	ND		
Weld	5/13	3	4-5	ND		
Weld	5/17	1	6	ND		
Logan	5/21	1	7	ND		
Weld	6/1	2	7	10.5	10±1.0	11±1.0
Morgan	6/7	1	8	170±2.0		
Denver	6/9	1	2	60±1.0		
Los Animas		4	4-6	26.5	5.0±3.0	49±2.0
Montezuma	6/21	5	4-12	240	ND	512±4.0
Boulder	6/23	1	4	ND		
Adams	6/24	2	5-6	120	ND	240±1.0
Elbert	6/25	5	6-8	ND		
LaPlata	6/28	4	6-7	119	62±2.0	197±2.0
Ga:						
Crawford	1/6	1	6	ND		
Hancock	1/8	1	6	ND		
Burke	1/13	1	6	ND		
Clarke	1/14	1	7	ND		
Fulton		1	6	1.9±1.3		
Wilkes		1	6	4.7±1.5		
Warren	2/4	1	8	3.4±0.9		
Pickens	2/22	1	7	ND		
Wilkes	2/25	1	9	ND		
Wilkes	3/4	1	2	ND		
Richmond	3/22	6	5-7	1.5	ND	2.5±1.0
Dade	3/26	1	6	ND		
Greene	4/16	1	11	ND		
Elbert	4/22	1	10	ND		
Wilkes		2	7-10	ND		
Richmond	4/23	1	7	2.3±1.0		
Hancock	4/30	2	6-7	1.8	1.5±0.9	2.2±0.8
Richmond	5/10	1	7	1.6±1.2		
Lincoln	5/27	1	6	ND		
Wilkes		1	7	2.0±1.0		
Columbia	6/9	1	3	36±1.0		
Butts	6/10	1	7	80±1.0		
Oconee		1	6	334±3.0		

See footnotes at end of table, p. 53.

Table 1. Iodine-131 in bovine thyroids, January–June 1965—Continued

State and county of origin	Date of slaughter (1965)	Number of samples	Age in years	pCi iodine-131/g thyroid		
				Average	Minimum	Maximum
Ga—Continued						
Wilkes	6/25	1	9	69±2.0		
Floyd		2	4	46	ND	91±1.0
Fulton		1	5	20±1.0		
Idaho:						
Bear Lake	5/4	10	2-8	35	19±0.6	52±0.9
Lemhi	5/18	7	5	2.0	1.5±0.6	3.3±0.8
Iowa:						
Lyon	6/8	8	5-10	821	35±1.0	1970±7.0
Kans:						
Jefferson	1/6	2	3	ND		
Leavenworth	3/24	1	7	ND		
Ky:						
Fayette	3/8	1	2	ND		
Clinton	3/25	3	5-7	ND		
Edmonson	6/4	1	6	404±4.0		
Harlan	6/9	1	6	379±4.0		
Metcalfe	6/29	2	6	158	119±2.0	196±3.0
Minn:						
Pipestone	2/26	2	2-5	ND		
Murray	3/25	2	7-9	ND		
Nobles	4/12	2	6-7	ND		
Nobles	4/15	2	5-6	ND		
Miss:						
Copiah	1/5	1	5	2.56±1.14		
Forrest		2	5-15	ND		
Lamar		1	15	ND		
Forrest	1/6	2	8-10	ND		
Jackson	1/8	2	6-7	ND		
Forrest	1/11	1	7	ND		
Forrest		7	4-7	ND		
Lamar		1	3	ND		
Marion		2	6-8	ND		
Forrest	1/20	8	6-8	ND		
Forrest	1/26	3	6-14	ND		
Lauderdale	1/28	1	15	ND		
Newton		1	6	ND		
Lauderdale	2/1	3	5-6	ND		
Forrest	2/5	1	5	ND		
Marion		2	6-8	ND		
Covington	2/9	6	2-7	ND		
Pearl River	2/22	2	6-7	ND		
Forrest	2/26	2	6-8	ND		
Forrest	3/4	2	9-12	ND		
Marion	3/8	3	9-11	ND		
Lamar	3/10	1	6	ND		
Forrest	3/12	2	5	ND		
Marion	3/22	10	4-10	ND		
Marion	4/2	10	4-9	ND		
N. Mex:						
Bernalillo	2/17	2	5-6	ND		
Quay		3	2-4	ND		
Bernalillo	2/24	5	5-7	ND		
Bernalillo	3/1	4	5-6	ND		
Bernalillo	3/8	5	5-8	ND		
Curry	3/10	3	6-10	ND		
San Miguel	3/15	5	3-6	ND		
Curry	3/17	4	3-6	ND		
Valencia	3/22	4	5-8	ND		
Bernalillo	3/23	3	5	ND		
Curry		21	6-10	ND		
Bernalillo	3/29	5	4-6	ND		
Curry	3/30	5	5-8	ND		
Bernalillo	4/12	4	3-10	ND		
Curry	4/13	4	5-9	ND		
Bernalillo	4/19	4	4-8	ND		
Torrance	4/28	4	9-11	<1	ND	2.3±0.9
Bernalillo	5/3	4	7-10	1.2	ND	1.9±1.3
Bernalillo	5/5	4	3-6	<1	ND	1.3±1.2
Bernalillo	5/10	4	5-7	ND		
Bernalillo	5/12	2	5	ND		
Torrance		1	8	ND		
Bernalillo	5/17	4	6-7	ND		
Torrance	5/19	4	9-12	ND		
Bernalillo	5/24	4	3-6	ND		
Bernalillo	5/26	4	3-9	4.8	ND	8.0±6.0
San Miguel	6/1	4	4-9	27	5.0±2.0	76±3.0
Bernalillo	6/2	4	3-6	46	8.0±1.0	130±3.0
Valencia	6/7	4	4-6	7[illegible]	5.0±1.0	165±3.0
Bernalillo	6/14	4	5-6	4[illegible]	37±2.0	54±2.0
Bernalillo	6/16	4	4-9	152	ND	442±4.0
Valencia	6/23	4	5-12	212	39±2.0	368±5.0
Bernalillo	6/30	4	4-6	39	26±1.0	52±1.0
N. Y:						
Cattaraugus	1/7	6	12	ND		
Cattaraugus	1/14	10	12	ND		

See footnotes at end of table, p. 53.

Table 1. Iodine-131 in bovine thyroids, January–June 1965—Continued

State and county of origin	Date of slaughter (1965)	Number of samples	Age in years	pCi iodine-131/g thyroid		
				Average	Minimum	Maximum
N. Y—Continued						
Cattaraugus	1/28	6	12	ND		
Cattaraugus	2/4	6	8–12	ND		
Cattaraugus	2/11	4	12	ND		
Cattaraugus	2/25	3	5	ND		
Cattaraugus	3/4	3	5–6	ND		
Chautauqua	3/11	4	5–6	ND		
Cattaraugus	3/18	6	9–11	ND		
Cattaraugus	4/1	1	11	ND		
Cattaraugus	4/22	3	10–13	ND		
Cattaraugus	4/29	4	1–14	<1	ND	1.2 ±0.9
Cattaraugus	5/6	8	6–15	<1	ND	1.1 ±0.9
Cattaraugus	5/20	3	4–14	ND		
Cattaraugus	5/21	4	1–11	<1	ND	2.4 ±1.2
Cattaraugus	5/27	3	7–9	66	10 ±2.0	146 ±3.0
N. Dak:						
Dickey	4/23	6	5–9	4.5	1.1 ±1.0	8.9 ±0.8
Okla:						
Cotton	4/2	1	7	ND		
S. C:						
Fairfield	5/12	2	7–8	2.8	2.3 ±0.8	3.2 ±1.1
S. Dak:						
Buffalo	1/15	21	6	ND		
Jerauld		2	7	ND		
Douglas	2/15	3	6	ND		
Lake	2/16	2	6	ND		
McCook		5	5–10	ND		
Beadle	2/24	3	3–8	ND		
Brown	2/25	3	7–14	ND		
Kingsbury		1	3	ND		
Turner	3/4	7	4–7	ND		
Aurora	3/5	1	14	ND		
Turner		1	12	ND		
Brule	3/9	5	4–8	ND		
Kingsbury		5	2–15	ND		
Turner	3/17	2	2–3	ND		
Minnehaha	3/18	1	15	ND		
Charles Mix	3/19	1	10	ND		
Turner		4	10–15	ND		
Douglas	3/25	8	6–10	ND		
Deuel	3/31	1	7	ND		
Hutchinson		1	8	ND		
Moody	4/1	1	9	ND		
Tripp	4/2	1	7	ND		
Aurora	4/7	10	5–6	ND		
Minnehaha	4/13	1	7	ND		
Brookings	4/14	2	5	ND		
Brown	5/7	1	5	1.0 ±0.5		
Lincoln		2	4–5	<1	ND	1.9 ±0.5
Minnehaha		2	5	ND		
McCook	5/11	1	3	1.6 ±1.1		
Turner		2	4	24	17 ±1.4	32 ±1.6
Lyman	5/13	3	5–6	7.3	ND	19 ±1.2
Brule	5/27	2	5–6	110	73 ±2.0	146 ±2.0
McCook		4	5–7	372	8.0 ±1.0	657 ±3.0
McCook	6/4	1	15	295 ±3.0		
Minnehaha		1	7	63 ±2.0		
Turner		6	4–15	346	165 ±2.0	540 ±3.0
McCook	6/9	1	9	116 ±2.0		
Turner		1	10	48 ±1.0		
Brown	6/24	9	8–11	154	84 ±2.0	235 ±2.0
Aurora	6/28	4	5–7	206	182 ±2.0	219 ±3.0
Minnehaha	6/30	6	4–8	177	90 ±2.0	228 ±2.0
Tenn:						
Loudon	1/8	1	2	ND		
Blount	1/14	10	3	ND		
Warren		2	3–5	<1	ND	1.5 ±1.4
Jefferson	2/5	1	4	ND		
Cocke	2/23	1	5	1.1 ±0.8		
Blount	3/8	1	4	ND		
Fayette		1	3	ND		
Fentress		1	4	ND		
Campbell	3/16	1	3	1.1 ±0.6		
Blount	3/25	3	2–3	ND		
Jefferson		3	5–6	1.6	1.3 ±1.2	1.9 ±1.1
Greene	3/26	3	3	ND		
Marion		3	4–6	ND		
Claiborne	5/26	1	8	7.0 ±1.0		
Monroe	5/27	1	9	8.0 ±1.0		
Anderson	6/3	4	4–7	522	439 ±3.0	681 ±6.0
Jefferson	6/7	1	6	324 ±3.0		
Monroe	6/8	1	2	447 ±4.0		
Greene	6/17	1	6	145 ±3.0		
Cocke	6/28	1	6	126 ±2.0		
Clay	6/29	1	6	83 ±2.0		
Tex:						
Wise	2/6	1	6	ND		
Collin	2/22	1	2	ND		
Wise	3/9	1	1	ND		

See footnotes at end of table, p. 53.

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Table 1. Iodine-131 in bovine thyroids, January–June 1965—Continued

State and county of origin	Date of slaughter (1965)	Number of samples	Age in years	pCi iodine-131/g thyroid		
				Average	Minimum	Maximum
Tex—Continued						
Ellis	5/19	1	6	ND		
Johnson		1	5	ND		
Tarrant		1	7	<1		
Tarrant	6/2	1	5	25 ±2.0		
Johnson	6/22	1	6	60 ±2.0		
Tarrant		2	5	12	11 ±1.0	13 ±1.0
Utah:						
San Juan	1/8	1	4	ND		
Sanpete	3/11	1	6	ND		
Sevier		2	7	ND		
Davis	3/12	1	3	ND		
Salt Lake		3	3-7	ND		
Utah		1	3	ND		
Weber		1	3	ND		
Juab	3/24	1	7	ND		
Utah		1	7	ND		
Wasatch		1	8	ND		
Box Elder	3/25	7	4	<1	ND	1.4 ±1.1
Salt Lake	3/29	3	8	ND		
Salt Lake	3/31	2	3	ND		
Cache	4/1	5	5	ND		
Cache	4/2	1	5	ND		
Weber	4/15	2	5-11	ND		
Unknown		3	6-7	ND		
Sevier	5/4	3	3-4	2.6	1.2 ±0.5	3.6 ±0.8
Sevier	5/5	2	3-4	<1	ND	1.8 ±0.7
Utah	5/12	5	4-5	<1	ND	1.6 ±0.7
Millard	5/26	1	8	73 ±1.0		
Weber		4	8	124	6.0 ±1.0	305 ±3.0
Weber	6/10	5	6-9	164	4.0 ±1.0	399 ±6.0
Utah	6/25	4	5-6	118	7.0 ±4.0	216 ±7.0
Vt:						
Franklin	2/18	5	3-5	ND		
Orleans		5	1-6	ND		
Franklin	2/23	2	7-8	ND		
Grand Isle		10	2-6	ND		
Orange		2	7-8	ND		
Franklin	3/1	10	2-6	ND		
Franklin	3/8	5	2-10	ND		
Grand Isle		1	5	ND		
Franklin	3/9	3	2-8	ND		
Franklin	3/15	10	2-5	ND		
Franklin	3/24	5	5-9	ND		
Orange		1	8	<1		
Franklin	4/5	8	5-9	ND		
Franklin	4/12	10	2-8	ND		
Franklin	4/19	5	3-6	ND		
Franklin	4/26	10	2-6	ND		
Franklin	5/3	9	4-8	<1	ND	<1
Franklin	5/10	10	3-6	ND		
Franklin	5/17	10	5-10	ND		
Franklin	6/1	8	3-8	29	3.0 ±1.0	45 ±1.0
Franklin	6/2	10	4	ND		
Franklin	6/14	6	5-9	126	11 ±1.0	224 ±2.0
Franklin	6/15	10	3-6	ND		
Franklin	6/29	16	2-7	16	ND	78 ±1.0
Wyo:						
Lincoln	5/18	1	4	<1		

[a] ND indicates observed value equal to or less than 2σ counting error.
[b] Purchased in Los Angeles County.
[c] Counting error is 2 standard deviations.

REPORTED NUCLEAR DETONATIONS, DECEMBER 1965

Three United States nuclear tests were announced by the Atomic Energy Commission during December 1965. All of the tests were conducted underground at the Nevada Test Site. A test of intermediate yield (200 kilotons to one megaton of TNT equivalent) was conducted on December 3. Two tests were conducted on December 16, one of low yield (less than 20 kilotons), and the other of low-intermediate yield (20 to 200 kilotons of TNT equivalent).

A British nuclear test, conducted underground on September 10, 1965, at the Nevada Test Site was reported to have been in the low-intermediate yield range.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 7, Number 2 February 1966

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Division of Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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Reports

PROGRESS ON METHODS FOR REDUCING STRONTIUM-90 IN WHEAT AND MILLED PRODUCTS

R. A. Anderson and *V. F. Pfeifer*[1]

SYNOPSIS—Various simple cleaning techniques were applied to four varieties of Kansas hard red winter wheat, to determine their effectiveness in removing strontium-90. As much as 73 percent of the strontium-90 content in wheat and 80 to 83 percent in bran was removed by washing with dilute phosphoric or citric acid. This treatment also produced substantial reductions in the strontium-90 content of flour.

The levels of strontium-90 in wheats grown in various parts of the United States are decreasing. In 1963, the average strontium-90 level in U.S. wheats was about 220 pCi/kg (*1*), and this level fell to approximately 135 pCi/kg in 1964 (*2*). Unless above-ground nuclear testing is resumed, this level is expected to decrease. In event of an emergency, however, in which there would be heavy contamination of wheat by radioactive fallout, information must be available to permit the decontamination of wheat, or milled products from it, to levels suitable for consumption in foods and feeds. This laboratory is investigating this problem and is developing methods to reduce the strontium-90 content in wheat and its milled products.

In wheat, the absorption of radioactive material depends upon the state of development of the plant at the time of fallout and upon the amount of rainfall during development of the heads. If rainfall is slight during and after head growth, the wheat will contain much less radioactivity than if the rainfall occurs during head formation. At present 80 to 90 percent of the strontium-90 in wheat results from foliar deposition of fallout and about 10 to 20 percent from root absorption from the soil (*3-5*). It was also found that the outer layers of the berry, the beeswing, and the bran layers were most heavily contaminated and that the endosperm was contaminated to a lesser degree (*6*).

The studies have been directed toward reducing radionuclide contamination in wheat by the application of simple cleaning techniques to the whole grain before milling.

Materials

These investigations were conducted on a wheat blend made up of four Kansas hard red winter wheats from the 1963 crop, selected on the basis of their strontium-90 level. The blend contained Bison, Pawnee, Tascosa, and Triumph varieties and had a strontium-90 content of 395 pCi/kg of wheat (as-is basis). This blend was milled on a Buhler[2] experimental mill into patent flour, clear flour, shorts, and bran that were analyzed for strontium-90.

Methods

Strontium-90 was determined by a modification of the method of Harley (*7*); however, procedures followed in the treatment and subsequent handling of the treated grain will be detailed. In all experiments, milling was carried out on the Buhler mill after the grain was tempered to 15 percent moisture overnight and to 15.5 percent 30 minutes before milling.

Dry treatment

The application of dry scouring or dehulling techniques to remove the outer layers of the wheat was carried out in three different machines; a Eureka laboratory wheat scourer, a

---

[1] Mr. Anderson and Mr. Pfeifer are chemical engineers at the Northern Utilization Research and Development Division, Agricultural Research Service. U.S. Department of Agriculture, located at Peoria, Illinois.

[2] Mention of firm names or trade products does not imply that they are endorsed or recommended by the Department of Agriculture over other firms or similar products not mentioned.

CeCoCo rice huller, and a Squiers rice huller. The wheat scourer consists of a rotor fitted with rubber paddles surrounded by a screen and equipped with aspiration devices. This machine subjected the wheat to a rather mild scouring action. The CeCoCo machine has a cone-shaped abrasive roll, for removing the outer layer of the grain, surrounded by a screen. The degree of hull removal by the machine is regulated by a weighted discharge gate, and any amount of the wheat may be abraded from the kernel. In the study, 4 to 17 percent of the kernel was removed. The Squiers huller is a machine for dehulling and polishing rice and consists of two sections. In the first section, a solid-cast rotor with several bars, surrounded by a screen, causes the grains to be rubbed against the rotor, screen, and one another, thereby removing the outer layers of the kernel. The second section contains a polisher, a series of leather straps that remove the remaining loosened, but adhering hull from the berry. In using this huller, we attempted to remove about 4 percent of the grain, which consisted primarily of beeswing, the outermost portion of the wheat. This particular procedure has been described by Earle (*8*).

After the wheat was treated in these three machines, the grain was milled, and the various fractions were analyzed (table 1).

Table 1. Scouring and dehulling wheat to reduce strontium-90

Treatment machine	Strontium-90 content after treatment, pCi/kg (as-is basis)					
	Wheat	Beeswing, dust, etc.	Bran	Shorts	Clears	Patent flour
Control	395		1,570	527	49	34
Scourer:						
1 pass, 0.5% removal		2,190	1,640	562	44	35
2 passes, 2.2% removal		2,040	1,380	484	54	37
CeCoCo dehuller:						
4% removal	302	3,200	1,320	540	55	37
7% removal	262	2,390	1,152	412	54	45
12% removal	235	1,870	1,180	470	54	42
17% removal	208	1,600	1,330	542	54	36
Squiers dehuller:						
4% removal	235	4,375	960	598	74	37

Mild scouring of the wheat removed only a small quantity of outer layer material and gave almost no reduction in strontium–90 in the milled fractions. The CeCoCo machine reduced strontium–90 by less than 25 percent when 4 percent of the grain was removed. When 17 percent of the grain was removed, strontium–90 was reduced by 47 percent. As the dehulling percentage increased beyond about 4 percent, the bran layer was attacked, and at 17 percent a sizeable amount of endosperm was also abraded. This loss of endosperm, of course, is undesirable from the millers' standpoint. Also, at the 12 and 17 percent removal levels the strontium–90 content of the bran and shorts fractions started to increase, after being reduced at the 4 and 7 percent levels.

Removal of essentially the outer layer of the wheat berry was best accomplished in the Squiers dehuller. By removing about 4 percent of the berry, about 40 percent of the strontium–90 was removed from the wheat with about the same reduction in the bran fraction. The other milled fractions did not change materially with respect to strontium–90 content. The high count in the outer layer fraction obtained by this treatment demonstrates the large degree of contamination on the outside of the grain.

Wet treatment

From data obtained in the dry milling experiments, it was obvious that another approach must be taken to the problem and that the application of wet or washing treatments to the grain should be investigated. Grain was washed in water for various periods of time, centrifuged, and dried. It was then tempered and Buhler milled into the usual fractions (table 2).

Table 2. Washing wheat with water to reduce strontium-90 content, temperature 75° F.

Treatment	Strontium-90 remaining, pCi/kg (as-is basis)					
	Wash time (hours)	Wheat	Bran	Shorts	Clears	Patent flour
Control		395	1,570	527	49	34
Distilled water	3½	426	1,561	627	44	33
Tap water [a]	1/60	365	1,388	455	44	32
Tap water [a]	3½	210	826	435	49	31
Tap water [a]	10	176	588	350	42	34
Tap water [a]	24	136	542	277	39	33
Tap water [a]	48	116	393	306	42	35

[a] Peoria, Illinois, tap water with a total hardness of about 300 ppm (as $CaCO_3$).

Washing the grain in distilled water gave essentially no reduction of strontium–90 in the wheat or its milled fractions, but washing with Peoria City tap water gave progressively greater reductions in strontium–90 in the wheat, bran, and shorts as the time of washing was increased. After 48 hours of washing, 71 percent of the strontium–90 was removed from the grain, reflected in decreases of 75 percent in the bran and 42 percent in the shorts fraction. Very little, if any, reduction of strontium–90 was obtained in the flour fractions by this treatment.

Washing wheat in certain dilute chemical solutions to reduce strontium–90 content was also studied. Additives were selected for their complexing, surface-acting, or sequestering properties, as well as their low cost and ready availability. In these experiments, grain was washed for 3½ hours in the appropriate solution with the solution replaced each hour. Two temperatures, 75°F. and 110°F., and two concentrations, 0.17 percent and 0.5 percent, were studied. After treatment, grain was centrifuged and dried. It was then tempered and milled as already described. Table 3 lists data obtained from chemical washings.

Table 3. Washing wheat with chemical additives to reduce strontium-90 content, wash time 3½ hours

Treatment	Strontium-90 content after treatment, pCi/kg (as-is basis)				
	Wheat	Bran	Shorts	Clears	Patent flour
Control (no washing)	395	1,570	527	49	34
Temp. 75°F. conc. 0.17%:					
Mixed phosphates	197	889	447	41	32
Citric acid	160	462	264	37	28
Gluconic acid	190	720	328		
Sodium gluconate	322	1,350	532		
Phosphoric acid	106	383	269		
Acetic acid	164	615	344		
Lactic acid	123	407	283		
Temp. 110°F. conc. 0.17%:					
Citric acid	117	338	174	42	28
Vel [a]	194	745	425		
Calgon [a]	139	460	251		
Phosphoric acid	113	328	212	29	30
Temp. 110°F. conc. 0.5%:					
Citric acid	105	300	137	27	26
Phosphoric acid	110	258	202	37	27

[a] Vel is a commercially available detergent, and Calgon is a mixture of food-grade sodium phosphate with soda ash and other carbonates of soda.

Significant reductions in the strontium–90 content of the wheat, bran, and shorts were accomplished by most of the treatments used. The best results were obtained with citric, lactic, and phosphoric acids. From 70 to 73 percent of the strontium–90 was removed from the wheat and up to 81 to 83 percent from the bran. There were substantial reductions in the strontium–90 content of clear and patent flours when citric and phosphoric acids were used. It appears that both temperature and concentration contribute to the decrease in strontium–90 in the wheat and milled fractions.

The combination treatment of dehulling and washing the dehulled wheat in citric or phosphoric acids did not reduce strontium–90 in the wheat and milled fractions any better than did washing alone. Indeed, washing the dehulled wheat had to be restricted to 1 hour because in a longer period the wheat became soggy and subsequent milling was affected.

Vacuum treatment

Washing the wheat in chemical solutions under relatively high vacuum was attempted in an effort to reduce the time involved. In these experiments, wheat was placed in a vacuum dryer, which was evacuated to about 28 inches Hg, and then the solution to be used was added. After the desired period of time, the vacuum was released, the solution drained, and the grain centrifuged and dried. The wheat was then tempered and milled in the usual manner. The data in table 4 indicate that it is necessary to have adequate contact time with the washing solution to obtain a significant reduction in strontium–90. Of the washes tried, the phosphoric acid gave the best results, particularly at the higher concentrations.

Table 4. Washing wheat under vacuum (28 inches Hg) to reduce strontium-90 content

Treatment	Strontium-90 content after treatment, pCi/kg (as-is basis)				
	Wheat	Bran	Shorts	Clears	Patent flour
Control	395	1,570	527	49	34
Temp. 75° F. 30 seconds:					
0.17% citric acid	269	1,050	523	41	34
Temp. 110° F. 10 minutes:					
0.17% citric acid	224	800	457	50	32
0.17% Vel	268	955	553		
0.17% phosphoric acid	211	685	298		
0.67% phosphoric acid	130	422	308		
Temp. 110° F. 30 minutes:					
0.17% phosphoric acid	136	530	294		
0.5% phosphoric acid	99	445	291		

Conclusions and future work

From the work completed to date, it is concluded that the strontium–90 content of wheat resulting from fallout can be reduced significantly by washing the grain in dilute phosphoric or citric acid. Reductions as high as 73 percent in the wheat and from 80 to 83 percent in the bran have been accomplished. Substantial reductions in strontium–90 in flour fractions have also been achieved. It must be pointed out, however, that the contaminated wheat studied was quite low in strontium-90, although it had the highest level obtainable in farm-grown wheat. We would expect considerably greater reductions in more heavily contaminated grain.

Future studies will be directed toward development of a simple, feasible, and economical method based on reported results. The effect of the additive, temperature, and other variables on the milled products, particularly the flour, is currently being considered. Changes in baking quality of the flour because of these factors will be critical for any method to be acceptable by millers. Preliminary farinograph and baking tests indicate that essentially no damage occurs to the flour as a result of the dilute acid treatments.

Acknowledgement

We are grateful to L. H. Burbridge, John Kerr, D. E. Uhl, F. B. Alaksiewicz, and L. P. Stoltz for their assistance throughout these studies.

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CESIUM-137 IN MILK, MEAT, AND MAN IN NORWAY, 1962-1965[1]

Kjell Madshus, Aksel Stromme, and Kristian Koren[2]

SYNOPSIS—Studies in Norway indicate regular seasonal patterns of cesium-137 concentrations in milk with a general increase in mean concentration from 75 pCi/liter in 1962 to 300 pCi/liter in 1965 in spring milk. Increases in cesium-137 body burdens from 16.0 to 80.9 nanocuries, observed from March 1963 through October 1964, roughly paralleled increases in milk concentrations of cesium-137 for this period. Results of anaylses for cesium-137 in lamb and beef ranging from 0.3 to 23.7 nCi/kg of meat are given, but no trends are indicated. Lamb showed higher concentrations than beef.

During the last few years, considerable interest has been expressed in determining the cesium-137 body burdens of humans. Particular emphasis has been placed upon those persons living at latitudes near the Arctic Circle.

This paper summarizes selected results from studies of cesium-137 concentrations in milk and meat, and the resultant body burdens in humans from Norway.

Milk

The cesium-137 content of Norwegian milk has been studied with particular interest. It is of significance to note that daily per capita milk consumption in Norway has increased from 0.59 liters in 1962 to 0.63 liters in 1964. However, effective comparison of the importance of cesium-137 in milk as related to the diet must also include the amounts of other dairy products consumed, such as cheese and butter.

Milk surveillance activities have been conducted in cooperation with the Norwegian Milk Producers National Association. Since February 1963, monthly samples have been collected from 30 dairies. The location of these dairies is given in figure 1.

For comparison purposes, one can from meteorological considerations divide Norway into three zones coinciding with the concentrations of cesium-137 in spring milk. These three zones are shown in figure 1.

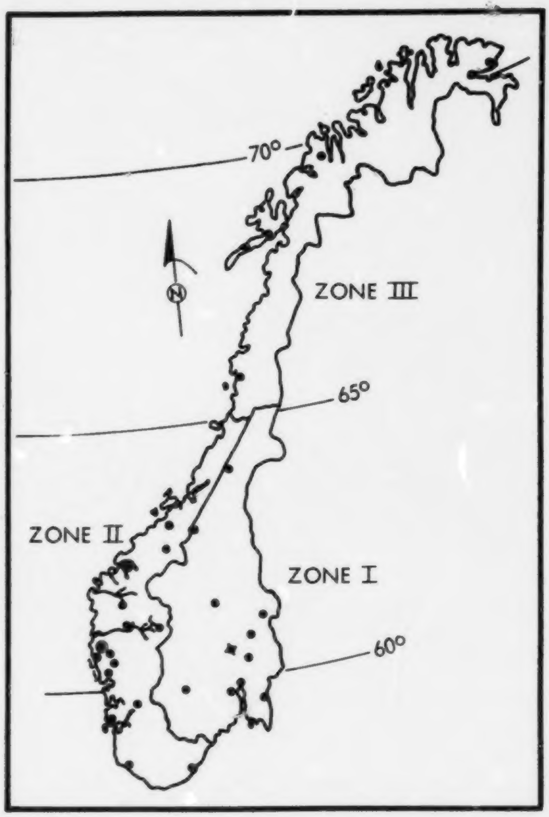

Figure 1. Norwegian zones and dairy locations

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[1] This work was supported by U.S. Atomic Energy Commission Contract No. AT (30-1)-3364.

[2] Mr. Madshus is a physics engineer at Norsk Hydros Institute for Cancer Research, Dr. Stromme is a physician at the Norwegian Radium Hospital, and Mr. Koren is the director of the State Institute of Radiation Hygiene in Norway.

The concentrations of cesium–137 varied considerably from dairy to dairy in the same county and often inversely with the amount of milk distributed by the dairy. Mean concentrations were therefore determined by weighting concentrations in each county or zone by the respective amount of milk distributed.

The monthly concentrations of cesium–137 in milk were observed to exhibit seasonal variation, with the minimum concentrations occurring between January and May each year. Figure 2 shows the average monthly concentration in each zone and in Norway as a whole for March 1963 through March 1965. The concentration curves exhibit the same patterns in each zone, with a minimum in late winter and spring, a rapid increase in June with a peak in late summer, and a decrease during the fall.

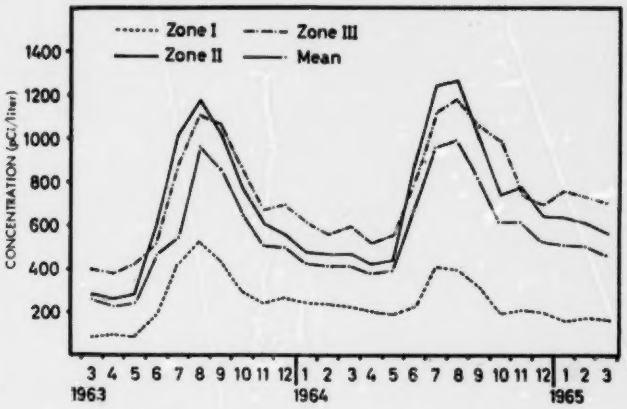

Figure 2. Seasonal variations of cesium–137 in cow's milk

From 1962 through the spring of 1965, the spring milk samples from almost all dairies showed an increase in cesium–137. The only exception is the 1965 spring milk from Zone I (see table 1). The mean concentration of cesium–137 in spring milk in Norway as a whole has increased from 75 pCi/liter in 1962 to 300 pCi/liter in 1965.

Table 1. Mean concentrations of cesium-137 (pCi/liter) in spring milk in the three zones and Norway, 1962–1965

Area	Mean concentration, (pCi/liter)			
	1962	1963	1964	1965
Zone I	25	80	195	155
Zone II	115	210	310	410
Zone III	220	245	435	555
Norway	75	145	265	300

Meat

As a part of these studies, meat from cows and 5-6-month old lambs from several Norwegian slaughterhouses where animals from the local districts are slaughtered (all together 28 slaughterhouses) has been systematically collected every 2 months. The locations of these slaughterhouses are shown in figure 3. All samples are taken from the same part of the animal, *i.e.*, the semi-tendinous muscle. This is a precaution taken because there are some reports which indicate that the concentration of cesium–137 can differ from muscle to muscle in the same animal (*1*). The age of the animal is not considered in this study.

Cows are slaughtered for meat all the year round, but lambs ordinarily are killed in late fall. The samples of beef and lambs' meat came from the same slaughterhouse except in two cases. All samples in this study are from late fall 1964.

Using the three arbitrary zones shown in figure 1, the results in this study are shown in table 2. From this table, no obvious correlation can be adduced between the concentrations of cesium–137 in lamb and beef.

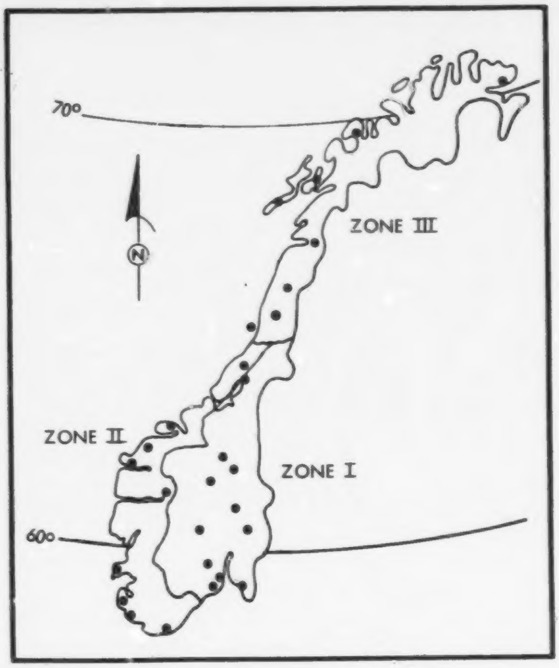

Figure 3. Slaughterhouse locations

Table 2. The mean, maximum, and minimum concentrations of cesium-137 in meat, late fall 1964 (nCi/kg fresh meat)

Area	Lamb (nCi/kg)			Beef (nCi/kg)		
	Mean	Maximum	Minimum	Mean	Maximum	Minimum
Zone I	6.7	17.4	1.6	0.9	2.6	0.3
Zone II	10.0	23.7	2.4	2.5	4.4	1.6
Zone III	8.5	14.7	4.0	2.3	4.1	0.8
Norway	8.2	23.7	1.3	1.8	4.4	0.3

Humans

The cesium-137 body burdens of 23 Norwegian schoolboys (from Zone 1) have been determined by means of a whole body counter at the Norsk Hydros Institute for Cancer Research (*1*) and are shown in table 3 and along with the spring milk data in figure 4. It can be seen that the body burdens increased from March 1963 through October 1964, roughly paralleling the milk cesium-137 values. In a study reported elsewhere, a trend toward higher cesium-137 body burden has been noted among those with a large milk consumption (*2*).

Table 3. The body burdens of cesium-137 in 23 Norwegian schoolboys from Zone I

Date measured	Body burdens, nCi		
	Mean	Maximum	Minimum
March 1963	23.2	16.0	43.5
October 1963	44.9	27.9	64.5
March 1964	47.2	24.8	67.5
October 1964	49.9	30.7	80.9

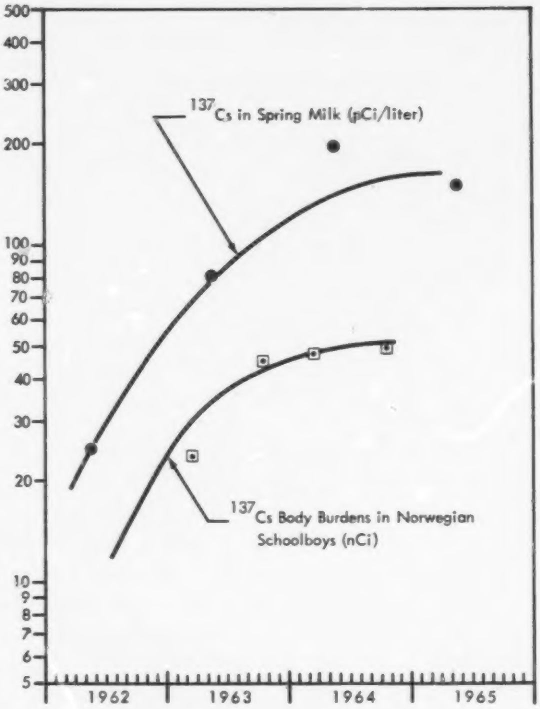

Figure 4. Norwegian cesium-137 milk concentrations and cesium-137 body burdens in schoolboys

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STRONTIUM-90 IN FOOD—A SUMMARY OF RESULTS ON SELECTED FOODS IN THE UNITED STATES, JULY 1962—OCTOBER 1963.

Lloyd R. Setter, Donald Smith, and Mozart Spector[1]

SYNOPSIS—Strontium-90 content and strontium-90/calcium ratios are summarized for nine staple foods sampled during a six-consecutive-quarter household survey which began in July 1962. The data are grouped into six broad geographical regions of production insofar as possible.

Strontium-90 concentrations in whole milk and evaporated milk showed regional differences and observable trends in a 3- or 6-month period; strontium-90 concentrations in bread had similar but less pronounced trends. Regional trends in strontium-90 were least discernible for potatoes, eggs, meat, fruit, and oleomargarine, due in part to the low strontium-90 content per unit weight and presumably to interregional shipment of food and feed. Foods such as cabbage, potatoes, and fruit had strontium-90/calcium ratios greater than those for whole milk and evaporated milk.

This study was conducted as part of a program to assess radiation exposure to the population from foods. The Division of Radiological Health collected selected food items from the principal marketing areas of the United States, and examined them for radionuclides. These food items were collected for six quarters beginning July 1962. This collection was made concurrently with a Food Consumption Survey which was conducted by the Bureau of Census for the first four of these six quarters in behalf of the Division of Radiological Health and the Division of Chronic Diseases. The Food Consumption Survey covers a representative sample of the U.S. population. This sample covered approximately 10,000 households comprising 30,000 persons who were surveyed during the first two weeks of each quarter (*1*, *2*).

This report summarizes the measurements of strontium-90 and the strontium-90 to calcium ratios in food samples collected during this study. During each survey period, the Division of Radiological Health arranged, through the PHS Division of Environmental Engineering and Food Protection, to have local food experts collect samples of each of the selected food items from the marketing centers. The selection of samples was based on the varieties and amounts of foods available at the time of sampling as indicated by appropriate USDA marketing reports and local marketing data.

Primary consideration was given to staple foods such as bread, fruit, milk, meat, and vegefor all six sampling periods. The fruit samples were apples for the first four samplings, and oranges for the last two. Whole milk samples were those of the Pasteurized Milk Network of the Division of Radiological Health, collected during each of the 2-week periods of sampling. The meat was ground chuck beef for the first four samplings, and lean pork for the last two. The green vegetable samples were lettuce for four samplings, and cabbage for two samplings. Evaporated milk was sampled for five periods, eggs and potatoes for four periods, and oleomargarine and breakfast cereal for two periods. Coffee beans and instant coffee were also sampled and tested. The results on coffee, however, showed that its contribution to strontium-90 intake was negligible in relation to total intake. For this reason, results of the coffee sampling have been omitted from this report. Table 1 lists the number of samples of each item collected in the conterminous United States for each sampling period.

Food sampling and analysis

The collected food samples were packaged and sent to regional laboratories of the Division of Radiological Health for determination of the radionuclides in the edible portion. In some instances, food wastes such as apple peel and core, or beef bone, were also examined.

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Table 1. Number of food samples collected in the conterminous United States during quarterly survey periods

Food samples	July 1962	Oct 1962	Jan 1963	Apr 1963	July 1963	Oct 1963	Total
Milk:							
Whole [1]	91	87	93	117	117	110	612
Evaporated	NS	48	35	34	25	28	170
Bread:							
White	61	50	44	45	55	53	308
Fruit:							
Apples	13	47	29	25	NS	NS	114
Oranges	NS	NS	NS	NS	14	11	25
Meat:							
Beef	13	14	13	12	NS	NS	52
Pork	NS	NS	NS	NS	21	25	46
Vegetables:							
Lettuce	40	26	24	15	NS	NS	105
Cabbage	NS	NS	NS	NS	24	32	56
Eggs	NS	NS	27	27	26	25	105
Potatoes	NS	NS	18	27	31	33	109
Oleomargarine	NS	NS	29	27	NS	NS	56
Cereal	NS	NS	NS	NS	34	32	66
Total	218	269	312	329	347	349	1,824

[1] Regular Pasteurized Milk Network samples of the Division of Radiological Health collected from the regional areas listed in figure 1.
NS, no samples collected.

Although only strontium-90 results are presented in this report, the analyses included determination of gamma-emitting radionuclides, barium-lanthanum-140, potassium-40, zinc-65, ziconium-niobium-95, cesium-137, ruthenium-103+106, iodine-131, and cerium-141+144, the radiochemical measurement of strontium-90, strontium-89, total radium, and the stable elements calcium, phosphorus, and potassium. Potassium was determined either by flame photometry or from the gamma measurement of potassium-40. A report on cesium-137 determinations and ^{137}Cs/K ratios is in preparation.

Interlaboratory comparison of analyses

Three laboratories of the Division of Radiological Health were primarily responsible for food analyses. Analytical control studies were conducted on portions of food ash from each of the type of foods sampled in the first three samplings. Ash samples were prepared from market foods and distributed to each of the Division's five laboratories for analyses. The results indicated that agreement between laboratories was satisfactory — generally within 25 percent of the mean for individual samples.

Regional comparisons

The regional areas selected for this study are those used by Morgan (*3*), except that the geographical pattern of strontium-90 concentrations in milk warranted a further subdivision of the West and the South. The West was divided into a Northwestern region including the States of Washington, Oregon, Idaho, Montana, and Wyoming; and a Southwestern region including the States of California, Nevada, Utah, Arizona, Colorado, and New Mexico. The strontium-90 concentrations in milk samples of the Southwestern region were usually less than those in samples of the Northwestern region. The strontium-90 in milk samples from the central part of the Southern region (namely, those samples collected from the area about 100 miles on either side of the Mississippi River from Memphis, Tennessee, to the Gulf of Mexico) appeared higher than that in other samples of the Southern region. When available for a particular food category, these have been listed in a "Delta" region. The geographical boundaries of the resulting six regions are shown in figure 1.

Further subdivision of components of the diet in the United States is not warranted, because food production, distribution, and marketing frequently assume a very complex pattern. For example, eggs are produced in every State of the Nation; however, the majority of the poultry feed is raised in the North Central United States. Beef animals raised on local pasture in one region may be fattened for market in another region on rations raised in a third region. The marketing of some products may be centralized. For example, the meat of over 80 percent of the beef animals is distributed from only 17 major markets in the United States. Whole milk, on the other hand, is largely of local origin throughout most of the United States. Therefore, the identification of food from production areas in the United States may be simple or very complex, but economical marketing usually favors a minimum cost of transportation.

Average strontium-90 concentrations in food

Data on strontium-90 and ratios of strontium-90 to calcium for each of the various food items are given in the appendix (page 74). The table consists of all the data on each food item for each sampling period. Waste portions of several samples which were composited and analyzed separately are also given.

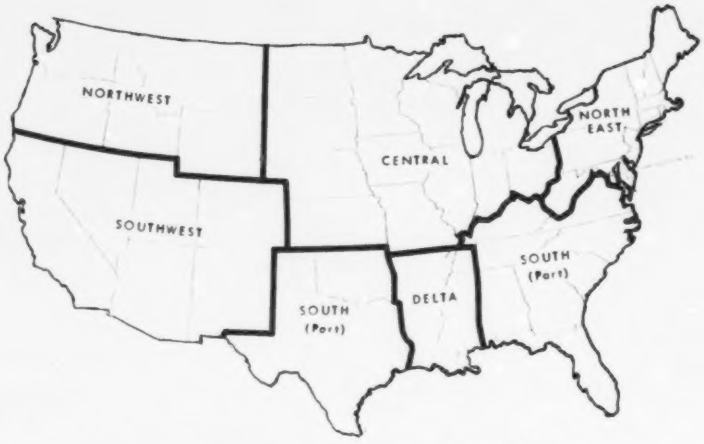

Figure 1. Regional areas for 1962–1963 food survey (modified regions used by Morgan—see reference 3)

The average strontium-90 concentration and the strontium-90/calcium ratio for each of the food items and for each quarter are shown in figure 2. Those foods sampled for at least five periods are listed in descending order of strontium-90 concentration: evaporated milk, whole milk, bread, vegetables, fruit, and meat. The remaining foods, which were sampled after the first two samplings, are eggs, potatoes, oleomargarine, and breakfast cereal, which are arranged in that order in approximately an ascending concentration of strontium-90 also shown for each sampling is the ratio of strontium-90 to calcium (pCi/g). It is interesting to note that the ratio for evaporated milk and whole milk is less than the numerical value of the concentration (pCi/liter, or pCi/kg), whereas the reverse is true for the other foods. This simply means that the calcium content per kilogram of evaporated milk or per liter of whole milk exceeds 1 gram, and for the remaining foods, the calcium is less than 1 gram per kilogram.

Because it is recognized that the human body discriminates against strontium in favor of calcium (*4*, *5*), consideration should be given to the relative importance of foods in the diet, based on both strontium-90 and calcium contributions. Thus, on a unit weight of food basis, it appears that breakfast cereal, green vegetables, fruit, potatoes, and meat would be rated of greater significance than milk products. This would be especially true if the dietary calcium requirements were supplied largely from foods such as those tested, other than the milk products.

Figure 2 reveals trends which appear significant. The bars for both evaporated milk and whole milk show increases in strontium-90 between the fourth and fifth samplings (April-July 1963). This is interpreted as the break between harvest years for the feeds. The remaining foods also show some evidence of a similar break and are, in part, the basis for evaluations on a harvest year, rather than a calendar year summation. In the case of some foods, such as apples (for four sampling periods), it appears that the first sampling reflects a carryover of produce from the previous harvest year. The fifth fruit sampling (oranges) similarly appears to be a mixture of food produced in two harvests. Eggs and meat, probably because the feed may be a mixture from many sources and several years, maintain a relatively uniform strontium-90 content during the period of the study.

Breakfast cereal had the highest strontium-90/calcium ratio (figure 2). There were variations of strontium-90 content and strontium-90/calcium ratios among the various kinds of cereal. No attempt was made to relate these samples to regions of production, since the number of samples was small and little information was available on the origin of the principal grain in the brand-name products. The results of these samples were grouped according to major grain component, averaged as shown in the appendix, and plotted in fig-

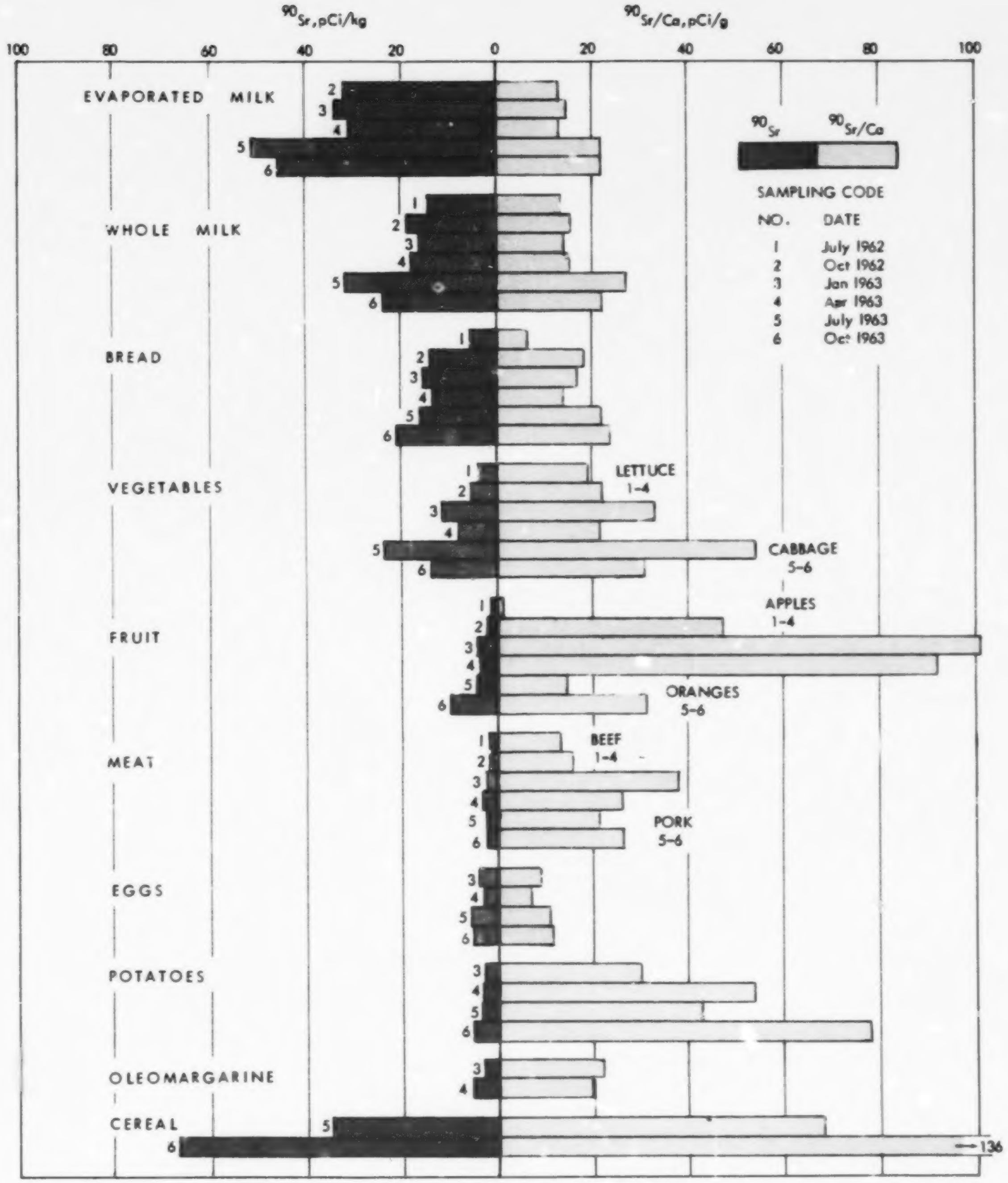

Figure 2. Strontium-90 and strontium-90/calcium ratios in foods, July 1962–October 1963

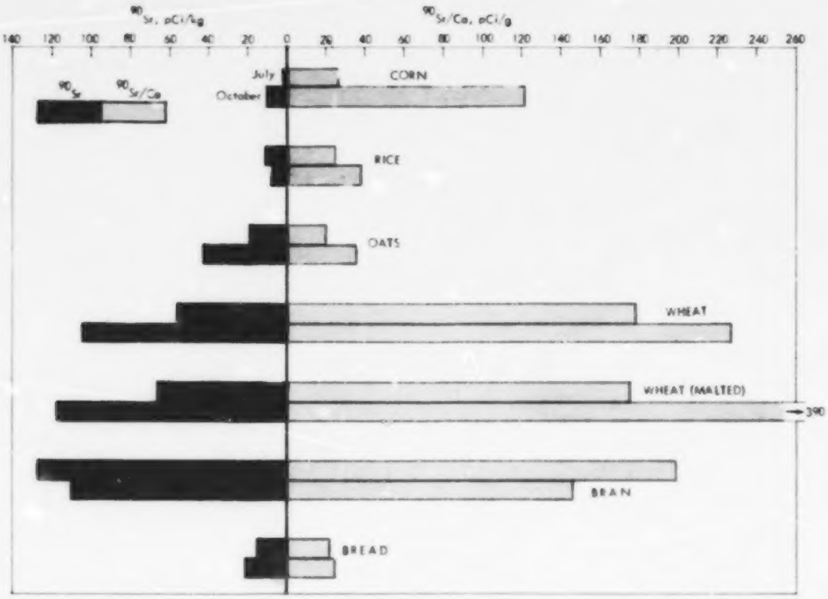

Figure 3. Strontium-90 in breakfast foods, July-October 1963

ure 3. The figure shows that breakfast products made from corn, rice, and oats are generally comparable to bread, whereas bran and whole wheat products tend to have higher strontium-90 concentration and strontium-90/calcium ratios.

Regional distribution of strontium-90 in food

The concentration of strontium-90 and the strontium-90/calcium ratios in milk and food samples for each sampling period are presented in figure 4. The average of the median and the mean has been adopted for graphic presentation. When the calcium content is less than 1 gram per kilogram of food, the ratio (shaded) is shown as a larger bar than strontium-90 concentration (solid). In the case of milk, the reverse order is evident.

Whole milk: The regional order of ascending concentration of strontium-90 and of strontium-90/calcium ratios in whole milk is Southwest, Northwest, Central, Northeast, South, and Delta. Over the six periods, the strontium-90/calcium ratio (average of mean and median) was 7.3 pCi/g for the Southwest and 26.3 for the Delta region, or a 3.6-fold spread. Moreover, a sharp rise in strontium-90 is apparent after the fourth sampling (between April 15 and July 1963) for the Northwest, Central, and Northeast regions. Also, a smaller but comparable rise appears between the third and fourth samplings (January 15 to April 1963) for the Southwest, South, and Delta regions. It is assumed that the increase in strontium-90 between these two dates indicates what may be termed the beginning of a new year for milk production and a new growth period for many crops.

Evaporated milk: The regional distribution and magnitude of the strontium-90/calcium ratios are, in general, similar to those for whole milk. The first four samplings for the Northwest showed similar concentrations and ratios to the Southwest, and both were generally lower than the Central region; the ratios for evaporated milk for the South resemble those for Delta whole milk. Considering that the inventory of evaporated milk is 1 to 3 months, and high exporting from the Central region was suspected, it is not unreasonable that the evaporated milk for the South and Delta regions would reflect the values for whole milk from Central, as well as local, production.

Bread and meat: These two commodities show little regional variations. A seasonal trend in a new harvest year for bread is indicated for the Southwest and the South, beginning April 1963, and for the Central and Northeast, beginning July 1963. No seasonal trend is shown for meat—due, in part, to the fact that the meat sampled was beef for four samplings, and lean pork for the last two.

Eggs and potatoes: The concentration of strontium-90 was low and comparable in these two foods, but potatoes are very low in calcium and hence had the highest strontium-90 calcium ratios of the food tested. There was, however, no substantial evidence of a regional variation and over the four sampling periods embracing two production seasons, no seasonal variation of importance.

Fruit and vegetables: Since there were different varieties of these, the regional differences, if any, are obscured. A gradual increase in the strontium-90 content in apples and in lettuce was observed for the first four samplings. The Southwest oranges, which were sampled in the fifth and sixth samplings, had considerably less strontium-90 than those of

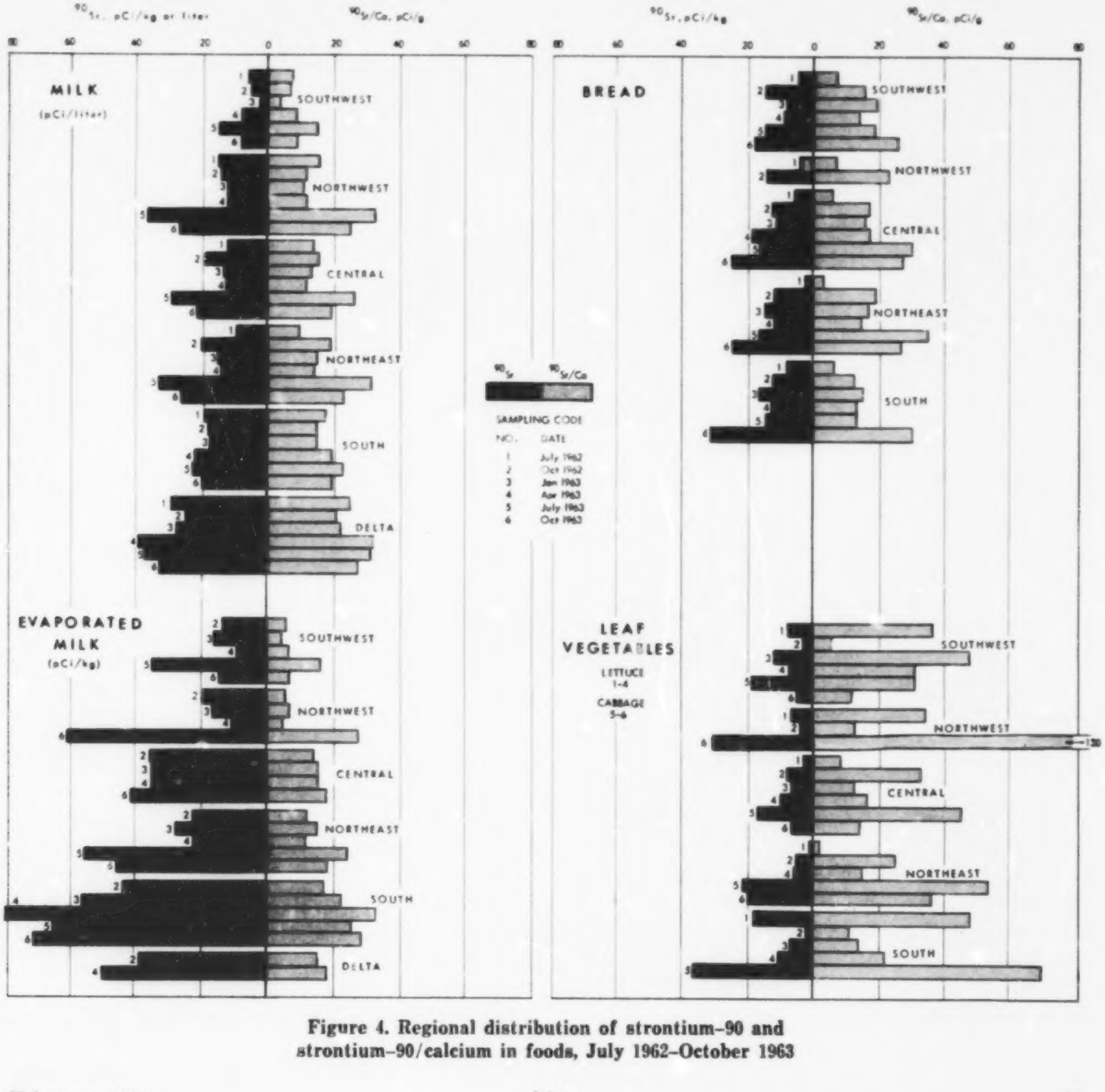

Figure 4. Regional distribution of strontium-90 and strontium-90/calcium in foods, July 1962–October 1963

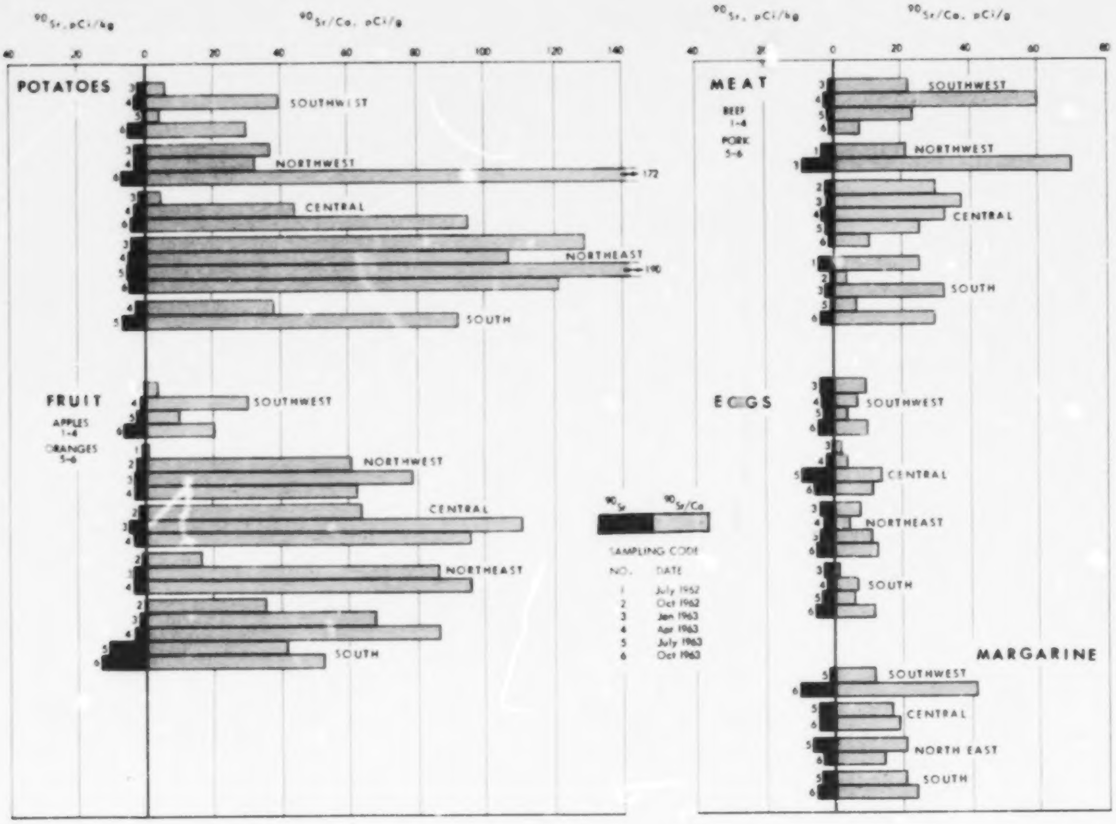

Figure 4—Continued

the South. The cabbages, sampled in the fifth and sixth samplings had higher strontium-90 contents in July than in October 1963. The differences between the values for cabbages in 1963 and lettuce in corresponding sampling periods of 1962 are consistent with the higher depositions of strontium-90 in the environment during 1963.

No marked regional or seasonal variation appears for lettuce, which was sampled for four samplings in one harvest year. The last two sampling results for cabbage fluctuated widely from one location to the next, thus obscuring any regional trends. It is important to note that although ranking fourth (after evaporated milk, whole milk and bread) in the survey's list of foods having the highest strontium-90 concentration, leaf vegetables had the highest strontium-90/calcium ratio of the first four foods.

Strontium-90 in harvest years

The 1963 spring rise in strontium-90 for whole milk, evaporated milk, bread, and leaf vegetables suggested that a harvest year be considered in evaluating the data. For this, the data of the first four quarters of the survey, July 1962 through April 1963, were grouped into harvest year 1962, and the samples of July and October 1963 in harvest year 1963. The annual average results for each food and region are given in tables 2 and 3 for the concentration of strontium-90 and the strontium-90/calcium ratio, respectively. The data are presented in figures 5 and 6 for harvest years 1962 and 1963. In these figures, the solid bars represent strontium-90 concentration in pCi/kg or, for whole milk, pCi/liter; the shaded bars represent the strontium-90 as pCi/g Ca.

The ascending order of regional magnitude

Table 2. Strontium-90 in foods by harvest year and region [a]

(pCi/kg)

Food item	United States	South-west	North-west	Central	North-east	South	Delta
Harvest year 1962							
Evaporated milk	28.2	[b]13.5	[b]15.8	[b]35.7	[b]24.3	[b]60.2	[c]44.0
Reconstituted [d]	14.2	6.8	8.0	18.0	12.3	30.4	22.2
Whole milk [e]	16.3	6.6	14.4	15.4	16.0	19.9	31.0
Bread	11.1	9.6	[c]9.0	13.7	[c]13.5	11.6	NS
Lettuce	7.4	7.2	[c]5.7	7.1	[b]2.5	9.2	NS
Apples	2.1	0.4	2.4	2.6	1.7	1.5	NS
Eggs	2.9	[c]4.2	NS	1.7	3.7	2.0	NS
Beef	1.6	1.0	NS	1.4	NS	[b]2.2	NS
Potatoes	3.0	[c]2.5	[c]3.0	[c]2.2	[c]4.2	[f]3.0	NS
Oleomargarine	2.2	[c]5.5	NS	[c]4.0	[c]4.5	[c]4.2	NS
Harvest year 1963 [a]							
Evaporated milk	48.7	25.5	[f]61.5	[f]42.0	50.5	70.5	NS
Reconstituted [d]	25.6	13.4	32.3	22.1	26.5	37.0	NS
Whole milk [e]	28.1	12.5	32.7	26.7	30.5	22.7	36.0
Bread	18.9	16.2	NS	20.7	20.7	22.5	NS
Cabbage	18.8	11.7	[f]33.0	11.7	20.7	[f]36.5	NS
Oranges	8.1	4.2	NS	NS	NS	12.0	NS
Eggs	5.4	3.8	NS	7.7	4.5	4.0	NS
Pork meat	1.8	1.5	NS	1.0	NS	2.0	NS
Potatoes	4.9	[f]3.2	[f]6.5	4.0	5.0	[f]6.5	NS
Cereal (bran)	51.0	NS	NS	NS	NS	NS	NS

[a] All samples are for four quarters in 1962 and two quarters in 1963, except as noted.

[b] Sampled three quarters.

[c] Sampled two quarters.

[d] Reconstituted to calcium content of whole milk.

[e] pCi per liter.

[f] Sampled one quarter.

NS, no sample collected.

Table 3. Strontium-90/calcium ratio in food by harvest year and region [a]

(pCi/g Ca)

Food item	United States average	South-west	North-west	Central	North-east	South	Delta
Harvest year 1962							
Evaporated milk	13.8	[b]5.0	[b]5.3	[b]15.7	[b]13.5	[b]25.2	[c]18.0
Whole milk	14.4	5.7	12.2	13.4	13.9	16.5	24.8
Bread	13.3	13.8	[c]14.5	13.5	13.4	11.8	NS
Lettuce	22.1	30.6	[c]24.2	17.6	[b]14.2	24.0	NS
Apples	44.5	8.4	50.8	67.2	49.1	47.2	NS
Eggs	5.3	[c]8.0	NS	3.0	6.2	4.2	NS
Beef	19.1	20.5	NS	31.0	NS	[b]15.5	NS
Potatoes	47.8	[c]22.5	[c]34.7	[c]24.5	[e]119.0	[d]38.0	NS
Oleomargarine	21.5	27.0	NS	18.0	18.2	22.7	NS
Harvest year 1963 [a]							
Evaporated milk	21.4	11.0	[d]28.0	[d]18.5	21.7	28.0	NS
Whole milk	23.0	11.0	28.0	22.7	26.5	20.5	29.2
Bread	26.0	22.0	NS	28.7	31.2	22.2	NS
Cabbage	30.3	22.0	[e]130.0	30.2	46.0	[d]69.5	NS
Oranges	30.8	15.2	NS	NS	NS	46.5	NS
Eggs	10.0	7.0	NS	12.5	12.0	8.5	NS
Pork meat	17.1	15.5	NS	17.7	NS	18.2	NS
Potatoes	87.5	[d]17.5	[d]77.0	95.0	156.0	[d]92.0	NS

[a] Sampled for four quarters in 1962 and for two quarters in 1963 except as noted.

[b] Sampled three quarters.

[c] Sampled two quarters.

[d] Sampled one quarter.

[e] Only two samples in one quarter. These were excluded from the U.S. average.

NS, no sample collected.

for both concentration and strontium-90/calcium ratio for whole milk in harvest year 1962 is Southwest, Northwest, Central, Northeast, South, and Delta. In 1963 the concentrations and ratios are higher, but the regional order has been altered somewhat, and differences between regions are less pronounced. The Southwest region has the lowest strontium-90 levels and strontium-90/calcium ratios for whole milk, evaporated milk, apples, oranges, and cabbage in both harvest years. It is also lowest for bread and eggs in harvest year 1963, but the regional differences for the harvest year averages are small for bread, eggs, lettuce, meat, oleomargarine, and potatoes.

The ratio of the average harvest year results in 1963 to those in 1962 was determined for the five foods common to both harvest years. These ratios are presented in table 4. It is of interest that the median ratio was found to be 1.8 for each food. The high and low ratios of from 0.9 to 4.6 for a particular region usually appear where the concentration of strontium-90 was low, such as in eggs, or where the number of samples in a regional group was small and consequently, less likely to be representative of the mean.

Table 4. Strontium-90 in 1963 harvest as compared to 1962 harvest

(Using average of strontium-90 concentrations and strontium-90/calcium ratios)

Food	South-west	North-west	Central	North-east	South	Delta	Median
Evaporated milk	2.0	4.6	1.2	1.8	1.1		1.8
Whole milk	1.9	2.3	1.7	1.9	1.2	1.2	1.8
Bread	1.6	NS	1.8	1.9	1.9	NS	1.8
Eggs	0.9	NS	4.3	1.6	2.0	NS	1.8
Potatoes	1.0	2.2	1.8	1.25	2.3	NS	1.8

NOTE: The foods listed were common to both harvest years. Those 1963/1962 strontium-90 ratios of food types for the U.S. which are not common are as follows: oranges to apples, 2.0; cabbage to lettuce, 2.0; and pork meat to beef, 1.0.

NS, no sample collected.

Summary and conclusions

This report summarizes results of analyses for strontium-90 in foods sampled for six quarters. The survey included samples of 5 to 10 staple foods collected during the first 2 weeks of each quarter from July 1962 through October 1963.

The data on the strontium-90 content and the strontium-90/calcium ratio for each food were grouped into six broad geographical regions of production insofar as possible, irrespective of the market from which it was sampled. An estimate of the strontium-90 concentrations and strontium-90/calcium ratios was derived from the mean and median values for each region.

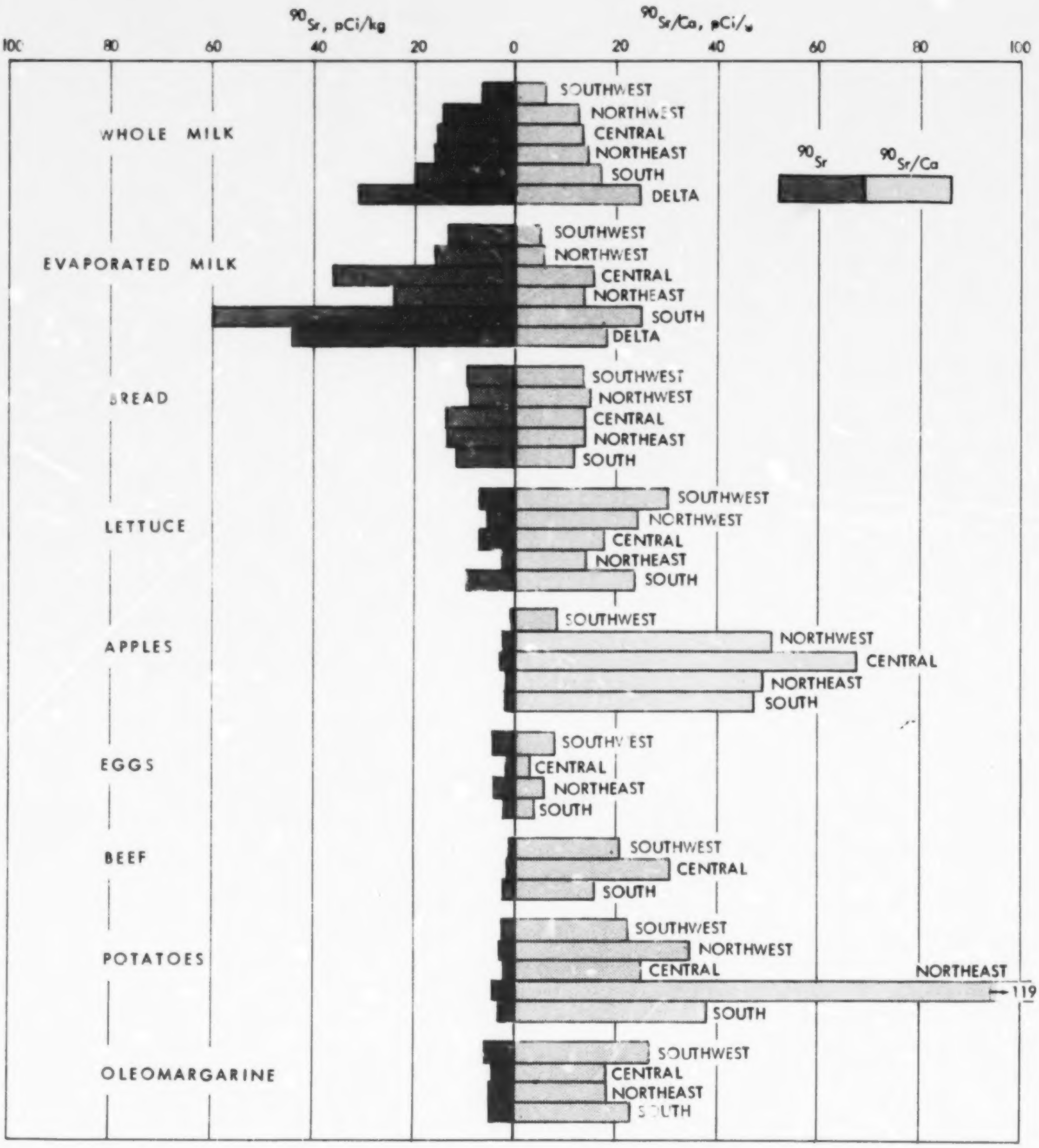

Figure 5. Regional distribution of strontium-90 in harvest year 1962 (samples of July 1962 through April 1963)

Examination of the strontium-90 concentrations and strontium-90/calcium ratios of the foods sampled suggests that whole milk provides a conservative index for estimating strontium-90 intake, unless an inordinately unbalanced food selection is made. Whole milk and evaporated milk tend to give regional differences and observable trends in a 3- or 6-month period; bread shows similar but less pronounced trends. Regional trends in strontium-90 were least discernible for potatoes, eggs, meat, fruit, and oleomargarine, due in part to

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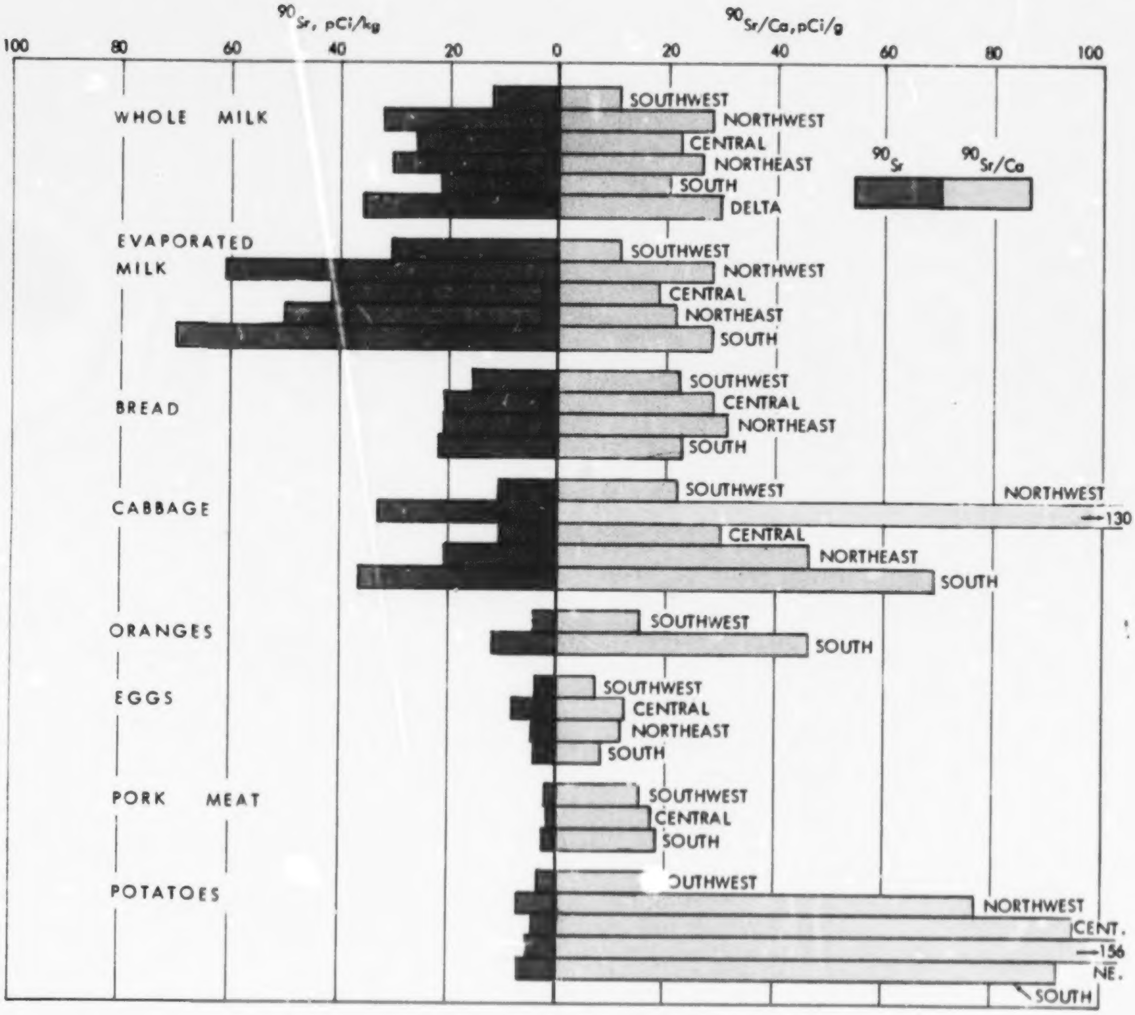

Figure 6. Regional distribution of strontium-90 in harvest year 1963 (samples of July–October 1963)

the low strontium-90 content per unit weight and presumably to interegional shipment of food and feed. Foods such as cabbage, potatoes, and fruit had low strontium-90 concentrations; strontium-90/calcium ratios are somewhat greater than those for whole milk and evaporated milk.

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Appendix. Strontium-90 in milk and food, July 1962–October 1963

Food	Region	Month and year	Number of samples	Strontium-90				Strontium-90/calcium (pCi/g)			
				Minimum	Maximum	Median	Mean	Minimum	Maximum	Median	Mean
Evaporated milk (Concentration in pCi/kg)	Southwest	1962									
		Oct	10	7	23	14	14	3	9	5	5
		1963									
		Jan	10	4	23	19	15	1	9	7	5
		Apr	9	2	19	10	9	1	5	4	4
		July	10	17	64	35	37	7	27	15	16
		Oct	7	0	37	15	15	0	9	6	7
	Northwest	1962									
		Oct	4	2	61	20	20	1	22	3	7
		1963									
		Jan	1	—	—	—	17	—	—	—	7
		Apr	3	10	14	10	11	4	5	4	4
		Oct	3	23	71	70	53	20	29	29	27
	Central	1962									
		Oct	16	15	92	35	38	6	36	14	16
		1963									
		Jan	8	17	59	35	36	7	25	16	16
		Apr	11	19	61	31	39	10	24	15	17
		Oct	3	0	65	47	37	0	27	20	17
	Northeast	1962									
		Oct	4	14	40	21	24	6	18	12	12
		1963									
		Jan	6	14	33	30	27	8	17	16	15
		Apr	5	18	25	22	22	11	14	13	13
		July	8	27	94	55	57	11	36	26	23
		Oct	8	21	85	43	49	9	35	18	20
	South	1962									
		Oct	10	6	78	44	43	3	30	19	18
		1963									
		Jan	10	27	78	55	57	15	33	22	24
		Apr	3	48	110	82	80	27	42	33	35
		July	7	26	122	64	66	11	49	26	27
		Oct	7	47	135	62	80	22	52	26	33
	Delta	1962									
		Oct	4	16	64	36	41	7	24	16	17
		1963									
		Apr	3	28	89	46	54	11	33	18	21
	United States	1962									
		Oct	48				32.2				13.1
		1963									
		Jan	35				33.8				14.5
		Apr	34				31.2				13.3
		July	25				51.7				22.0
		Oct	28				45.7				22.0
Milk, fluid (Concentration in pCi/liter)	Southwest	1962									
		July	13	3	21	5	9	2	20	4	9
		Oct	7	2	11	5	6	2	9	6	5
		1963									
		Jan	7	2	12	2	5	2	9	2	4
		Apr	14	3	33	7	12	3	27	6	10
		July	14	2	42	15	17	2	35	13	15
		Oct	10	2	20	8	10	2	16	7	9
	Northwest	1962									
		July	10	13	21	16	16	12	20	14	16
		Oct	9	11	25	15	16	8	19	11	11
		1963									
		Jan	6	11	16	13	13	8	13	9	11
		Apr	12	9	17	13	13	7	13	11	11
		July	12	29	59	39	37	24	49	32	32
		Oct	11	17	37	29	27	14	32	24	24
	Central	1962									
		July	24	4	30	12	15	3	28	13	14
		Oct	25	13	31	21	20	10	23	15	15
		1963									
		Jan	22	8	28	14	14	7	16	12	14
		Apr	30	8	22	13	14	6	21	11	12
		Jul	30	19	67	29	32	19	67	25	27
		Oct	29	13	54	21	25	11	47	18	21
	Northeast	1962									
		July	27	4	25	10	11	3	22	8	10
		Oct	27	10	32	22	23	10	26	18	19
		1963									
		Jan	28	10	24	16	16	9	21	14	15
		Apr	29	10	26	14	16	9	22	13	14
		July	30	26	57	36	32	22	46	30	32
		Oct	30	20	41	27	27	16	34	22	22
	South	1962									
		July	10	5	31	20	19	14	26	17	17
		Oct	12	9	28	19	18	8	23	14	15
		1963									
		Jan	23	10	26	18	18	8	21	15	15
		Apr	24	12	32	24	23	10	25	20	19
		July	23	8	48	22	26	7	47	21	23
		Oct	22	16	33	20	23	14	28	18	20

Appendix—continued

Food	Region	Month and year	Number of samples	Strontium-90				Strontium-90/calcium (pCi/g)			
				Minimum	Maximum	Median	Mean	Minimum	Maximum	Median	Mean
Milk, fluid —Continued	Delta	1962									
		July	7	24	37	30	30	19	31	25	25
		Oct	7	18	33	25	25	15	26	20	20
		1963									
		Jan	7	24	30	30	27	18	21	15	15
		Apr	8	34	46	40	40	27	25	20	19
		July	8	32	41	38	38	27	33	31	31
		Oct	8	26	38	34	33	22	31	28	27
	United States	1962									
		July	91				14.7				13.5
		Oct	87				19.0				15.4
		1963									
		Jan	93				16.2				14.2
		Apr	117				17.8				15.1
		July	117				31.8				27.3
		Oct	110				24.5				22.1
Bread (Concentration in pCi/kg)	Southwest	1962									
		July	8	2	10	5	5	2	16	6	7
		Oct	10	0	24	17	14	0	28	16	16
		1963									
		Jan	13	0	87	7	15	0	145	14	24
		Apr	15	0	16	10	9	0	20	14	13
		July	12	5	27	16	15	4	26	18	18
		Oct	11	0	35	20	17	2	62	27	25
	Northwest	1962									
		July	9	3	18	3	5	3	26	5	8
		Oct	4	9	23	13	15	10	36	22	23
	Central	1962									
		July	13	2	11	6	7	1	14	5	6
		Oct	26	2	59	11	15	1	151	12	21
		1963									
		Jan	10	10	26	16	17	9	32	15	16
		Apr	10	4	28	19	19	3	33	16	17
		July	20	10	32	15	18	11	100	33	27
		Oct	20	0	47	25	25	0	61	29	26
	Northeast	1962									
		July	10	0	8	3	3	0	9	3	3
		Oct	5	6	22	11	13	4	29	20	18
		1963									
		Jan	10	3	23	15	15	3	29	18	16
		Apr	10	7	21	11	13	6	40	15	14
		July	11	10	27	15	18	23	96	35	36
		Oct	7	5	34	26	24	6	68	26	28
	South	1962									
		July	16	0	19	8	8	0	15	6	8
		Oct	11	8	21	12	12	6	19	12	12
		1963									
		Jan	11	7	24	17	15	6	28	15	15
		Apr	10	7	21	12	13	6	22	14	12
		July	12	4	28	14	14	3	28	13	14
		Oct	15	17	48	31	31	19	48	30	32
	Delta	1962									
		July	5	0	7	0	2	0	6	0	3
	United States	1962									
		July	61				5.6				6.2
		Oct	50				13.9				17.9
		1963									
		Jan	44				15.5				17.4
		Apr	45				13.2				13.8
		Jul	55				16.5				21.9
		Oct	53				21.3				23.7
Lettuce (Concentration in pCi/kg)	Southwest	1962									
		July	8	0	38	4	11	0	90	30	44
		Oct	9	0	10	2	4	0	30	3	9
		1963									
		Jan	15	0	66	8	15	0	140	41	56
		Apr	6	0	15	7	7	0	50	30	32
	Northwest	1962									
		July	5	3	10	7	7	23	47	35	36
		Oct	4	0	19	2	6	0	61	7	19
	Central	1962									
		July	16	0	8	3	3	0	20	7	9
		Oct	6	2	20	8	9	12	59	32	34
		1963									
		Jan	6	3	18	6	8	4	25	12	13
		Apr	4	0	15	11	9	0	19	18	16
	Northeast	1962									
		July	10	0	3	0	1	0	11	0	4
		Oct	6	0	15	5	5	0	100	19	32
		1963									
		Apr	1	—	—	—	6	—	—	—	15

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Appendix—continued

Food	Region	Month and year	Number of samples	Strontium-90				Strontium-90/calcium (pCi/g)			
				Minimum	Maximum	Median	Mean	Minimum	Maximum	Median	Mean
Lettuce–Continued	South..........	1962									
		July	1	—	—	—	18	—	—	—	48
		Oct	1	—	—	—	2	—	—	—	11
		1963									
		Jan	3	0	8	8	5	0	20	13	16
		Apr	4	3	15	11	10	14	30	22	23
	United States...	1962									
		July	40				4.5				19.1
		Oct	26				5.9				22.1
		1963									
		Jan	24				11.9				33.2
		Apr	15				8.3				21.8
Cabbage (Concentration in pCi/kg)	Southwest......	1963									
		July	4	0	40	20	17	0	70	26	38
		Oct	6	0	17	4	6	0	41	10	14
	Northwest	1963									
		Oct	2	24	43	33	33	126	134	130	130
	Central.........	1963									
		July	4	2	31	17	17	5	89	50	42
		Oct	11	0	17	6	7	0	41	13	16
	Northeast......	1963									
		July	11	5	80	20	23	23	143	48	60
		Oct	13	2	52	19	21	5	149	34	42
	South..........	1963									
		July	5	8	72	39	35	20	157	76	63
	United States...	1963									
		July	24				23.5				54.0
		Oct	32				14.1				31.8
Waste		1963									
		July	6	38	208	94	106	64	246	170	147
		Oct	8	15	122	56	57	17	130	36	55
Apples (Concentration in pCi/kg)	Southwest......	1962									
		July	1	—	—	—	0	—	—	—	0
		Oct	5	0	2	0	<1	0	33	0	7
		1963									
		Jan	2	0	0	0	0	0	0	0	0
		Apr	2	0	3	1	2	0	60	30	30
	Northwest......	1962									
		July	4	0	8	0	2	0	2	0	1
		Oct	4	0	14	1	4	0	467	0	121
		1963									
		Jan	5	0	26	0	6	0	650	0	156
		Apr	6	0	22	1	5	0	314	20	104
	Central.........	1962									
		July	4	0	0	0	0	0	0	0	0
		Oct	15	0	4	2	2	0	133	67	60
		1963									
		Jan	8	2	9	5	5	50	225	100	121
		Apr	4	0	6	4	3	0	150	100	90
	Northeast......	1962									
		July	2	0	0	0	0	0	0	0	0
		Oct	15	0	9	0	2	0	125	0	32
		1963									
		Jan	10	2	9	3	4	60	450	75	97
		Apr	10	0	11	3	4	0	275	83	106
	South..........	1962									
		July	2	0	0	0	0	0	0	0	0
		Oct	8	0	3	0	1	0	100	33	38
		1963									
		Jan	4	2	2	2	2	50	100	67	67
		Apr	3	0	4	4	3	0	100	100	73
	United States...	1962									
		July	13				0.6				1.5
		Oct	47				1.8				47.0
		1963									
		Jan	29				3.9				102.0
		Apr	25				3.5				92.0
Oranges (Concentration in pCi/kg)	Southwest......	1963									
		July	12	0	9	2	3	0	19	10	10
		Oct	9	0	45	4	9	0	115	12	29
	South..........	1963									
		July	2	11	11	11	11	30	52	41	41
		Oct	2	6	19	13	13	14	90	52	52
	United States...	1963									
		July	14				4.1				14.0
		Oct	11				10.0				31.0
Waste		1963									
		July	8	6	46	13	18	4	54	12	14
		Oct	3	16	75	30	40	3	14	50	34

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Appendix—continued

Food	Region	Month and year	Number of samples	Strontium-90				Strontium-90/calcium (pCi/g)			
				Minimum	Maximum	Median	Mean	Minimum	Maximum	Median	Mean
Eggs (Concentration in pCi/kg)	Southwest	1963									
		Jan	8	2	34	2	7	4	72	5	13
		Apr	12	0	26	3	5	0	53	5	9
		July	4	0	5	3	3	0	9	3	5
		Oct	5	3	6	5	4	6	13	10	10
	Central	1963									
		Jan	6	0	5	0	1	4	72	5	13
		Apr	6	0	3	3	2	0	53	5	9
		July	8	0	37	8	11	0	64	16	12
		Oct	6	3	8	6	6	8	15	11	11
	Northeast	1963									
		Jan	7	2	7	4	4	4	13	7	8
		Apr	6	0	4	3	3	0	7	5	5
		July	9	3	8	4	4	6	21	11	11
		Oct	8	3	8	5	5	9	17	13	13
	South	1963									
		Jan	6	0	5	3	2	0	10	0	3
		Apr	3	0	3	2	2	0	7	7	7
		July	5	0	4	3	3	0	8	6	5
		Oct	6	0	13	5	5	0	21	11	12
	United States	1963									
		Jan	27				3.9				8.6
		Apr	27				3.3				6.8
		July	26				5.7				10.9
		Oct	25				5.2				11.4
Beef (Concentration in pCi/kg)	Southwest	1962									
		July	3	0	0	0	0	0	0	0	0
		Oct	2	0	0	0	0	0	0	0	0
		1963									
		Jan	4	0	4	1	2	0	57	17	26
		Apr	4	2	6	2	3	50	120	50	71
	Northwest	1962									
		July	2	0	4	2	2	0	44	22	22
		1963									
		Jan	1	—	—	—	9	—	—	—	69
	Central	1962									
		July	3	0	0	0	0	0	0	0	0
		Oct	7	0	4	2	2	0	67	33	27
		1963									
		Jan	6	0	5	2	2	0	83	38	37
		Apr	8	0	6	3	3	0	67	33	31
	South	1962									
		July	5	0	7	3	5	0	41	25	26
		Oct	5	0	4	0	1	0	33	0	7
		1963									
		Jan	2	0	4	2	2	0	57	33	33
	United States	1962									
		July	13				1.4				13.4
		Oct	14				1.3				16.0
		1963									
		Jan	13				2.5				38.5
		Apr	12				2.8				26.3
Pork (Concentration in pCi/kg)	Southwest	1963									
		July	3	0	4	2	2	0	33	25	21
		Oct	2	0	2	1	1	0	17	8	8
	Central	1963									
		July	11	0	4	2	2	0	200	20	29
		Oct	15	0	8	0	1	0	160	0	22
	South	1963									
		July	7	0	6	0	1	0	32	0	13
		Oct	8	0	16	3	4	0	145	22	38
	United States	1963									
		July	21				2.0				21.5
		Oct	25				2.0				26.7
Waste bone		1963									
		July	9	308	1,480	566	693	4	34	15	13
		Oct	13	260	811	469	525	3	17	8	9

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Appendix—continued

Food	Region	Month and year	Number of samples	Strontium-90				Strontium-90/calcium (pCi/g)			
				Minimum	Maximum	Median	Mean	Minimum	Maximum	Median	Mean
Potatoes (Concentration in pCi/kg)	Southwest	1963									
		Jan	2	0	4	2	2	0	8	4	8
		Apr	4	2	5	3	3	15	71	42	36
		July	16	0	6	0	1	0	150	0	9
		Oct	4	0	12	5	5	0	60	32	29
	Northwest	1963									
		Jan	5	9	5	3	3	0	71	37	37
		Apr	4	2	4	3	3	28	38	33	32
		Oct	7	0	25	5	8	0	420	50	104
	Central	1963									
		Jan	3	0	2	2	1	0	33	4	7
		Apr	9	0	7	3	3	0	175	40	47
		Oct	12	2	8	4	4	0	200	100	90
	Northeast	1963									
		Jan	8	3	5	4	4	80	200	141	121
		Apr	8	3	9	4	5	67	167	100	115
		July	6	0	24	4	6	0	800	184	195
		Oct	10	2	9	4	5	33	700	125	120
	South	1963									
		Apr	2	2	3	3	3	33	43	38	38
		July	9	4	10	6	7	13	700	120	65
	United States	1963									
		Jan	18				2.9				30.0
		Apr	27				3.6				54.0
		July	31				3.6				43.0
		Oct	33				5.3				78.0
Waste		1963									
		July	9	2	17	10	11	50	1,003	106	117
		Oct	5	5	16	12	12	17	123	92	69
Oleomargarine (Concentration in pCi/kg)	Southwest	1963									
		Jan	7	0	3	0	1	0	200	4	20
		Apr	6	6	16	10	10	22	67	44	40
	Central	1963									
		Jan	3	3	4	4	4	14	21	17	17
		Apr	9	2	6	4	4	0	25	19	19
	Northeast	1963									
		Jan	8	2	12	6	6	10	54	17	26
		Apr	4	2	4	3	3	12	18	15	15
	South	1963									
		Jan	11	0	7	4	3	0	300	21	21
		Apr	8	0	11	5	5	0	50	22	27
	United States	1963									
		Jan	29				3.4				22.5
		Apr	27				5.4				19.5
Cereal											
Corn		1963									
		July	8	0	6	3	3	0	200	32	20
		Oct	7	2	35	6	15	50	1,033	115	131
Wheat		1963									
		July	9	20	110	52	62	80	447	162	195
		Oct	10	27	156	110	99	44	495	230	223
Oats		1963									
		July	4	0	25	23	14	0	125	29	10
		Oct	4	7	83	42	43	5	117	42	30
Rice		1963									
		July	8	0	25	10	12	0	42	23	29
		Oct	5	2	18	7	8	11	120	32	45
Wheat, malted		1963									
		July	3	48	74	66	63	114	211	183	160
		Oct	2	95	140	118	118	352	425	390	390
Bran		1963									
		July	2	88	187	128	128	196	220	108	208
		Oct	4	19	430	68	146	25	377	100	179
Small grain[a]		1963									
		July	26				45				83
		Oct	25				82				138
	United States	1963									
		July	34				35				68
		Oct	32				67				136

[a] Summary of all grains except corn.

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Data

Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the United States population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the International Commission on Radiological Protection (*4, 5*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross section of routine sampling programs which may be considered of a continuing nature. For milk, routine sampling has been defined as one or more samples collected per month.

NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk. Data from the Pasteurized Milk Network (U.S.), Canadian Milk Network and Pan American Milk Network are presented below.

1. Pasteurized Milk Network October 1965

Division of Radiological Health and Division of Environmental Engineering and Food Protection, PHS

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State. In addition, milk is sampled in the Canal Zone and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 issue of *Radiological Health Data* (*6*).

The results for October 1965 and third quarter of 1965 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples collected weekly. If radionuclide values were below minimum detectable concentrations (*6*), averages were calculated using one-half the minimum detectable value; however, for iodine–131 and barium–140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

For comparative purposes, distributions of strontium–90 and cesium–137 are presented in tables 2 and 3 for May through October 1965 and October 1964. The average strontium–90 concentrations in pasteurized milk from selected cities are presented in figure 2.

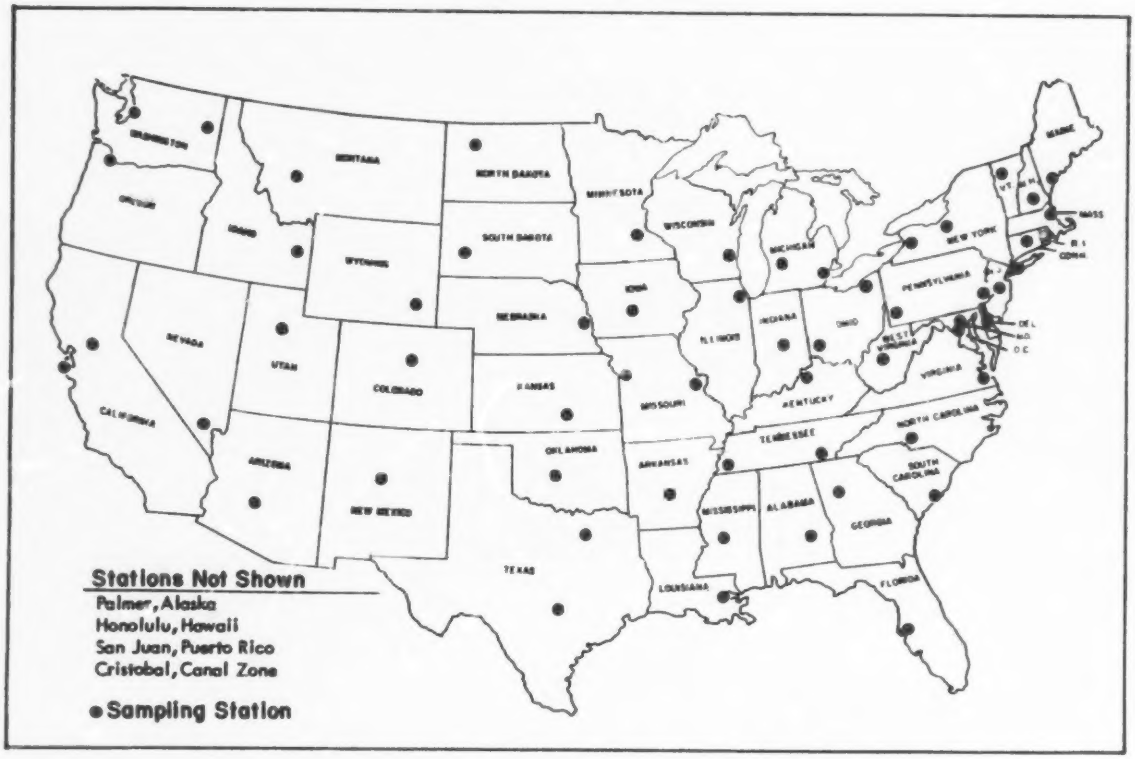

Figure 1. Pasteurized Milk Network sampling stations

Table 1. Average concentrations of stable elements and radionuclides in pasteurized milk for the third quarter and October 1965 [a]

Sampling locations		Calcium (g/liter)		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)	
		Third quarter	October	Third quarter	October	Third quarter	October	Third quarter	October
Ala:	Montgomery	1.14	1.17	<5	<5	14	15	40	30
Alaska:	Palmer	1.22	1.41	<5	<5	15	12	50	50
Ariz:	Phoenix	1.22	1.24	<5	<5	4	3	20	10
Ark:	Little Rock	1.14	1.19	5	<5	28	28	50	30
Calif:	Sacramento	1.28	1.28	<5	<5	5	4	25	10
	San Francisco	1.25	1.27	<5	<5	5	3	20	15
C. Z:	Cristobal	1.10	1.14	<5	<5	4	13	30	35
Colo:	Denver	1.28	1.28	<5	<5	14	13	40	25
Conn:	Hartford	1.09	1.11	<5	<5	13	13	50	40
Del:	Wilmington	1.11	1.14	<5	<5	15	16	40	30
D. C:	Washington	1.13	1.13	<5	<5	13	13	30	20
Fla:	Tampa	1.16	1.16	<5	<5	12	13	175	150
Ga:	Atlanta	1.14	1.16	<5	<5	20	19	55	45
Hawaii:	Honolulu	1.16	1.16	<5	<5	6	8	40	40
Idaho:	Idaho Falls	1.27	1.26	<5	<5	16	12	50	40
Ill:	Chicago	1.11	1.13	<5	<5	11	12	35	35
Ind:	Indianapolis	1.11	1.16	<5	<5	12	12	25	25
Iowa:	Des Moines	1.23	1.25	<5	<5	16	15	30	20
Kans:	Wichita	1.19	1.23	<5	<5	14	14	25	20
Ky:	Louisville	1.12	1.14	5	<5	18	18	25	20
La:	New Orleans	1.18	1.22	<5	<5	33	31	60	45
Maine:	Portland	1.11	1.14	5	<5	20	15	90	65
Md:	Baltimore	1.11	1.15	<5	<5	15	16	40	25
Mass:	Boston	1.10	1.13	5	<5	19	17	80	55
Mich:	Detroit	1.09	1.11	<5	<5	11	12	35	30
	Grand Rapids	1.13	1.16	<5	<5	14	15	45	40
Minn:	Minneapolis	1.28	1.26	5	<5	23	22	50	40
Miss:	Jackson	1.18	1.19	<5	<5	25	25	40	30
Mo:	Kansas City	1.21	1.21	5	<5	18	16	25	20
	St. Louis	1.22	1.23	5	<5	16	17	25	20
Mont:	Helena	1.27	1.32	5	<5	18	13	55	45
Nebr:	Omaha	1.22	1.20	<5	<5	16	16	30	30
Nev:	Las Vegas	1.20	1.33	<5	<5	5	4	20	25
N. H:	Manchester	1.11	1.14	<5	<5	21	19	105	70
N. J:	Trenton	1.09	1.12	<5	<5	14	11	40	30
N. Mex:	Albuquerque	1.24	1.22	<5	<5	6	4	20	20
N. Y:	Buffalo	1.09	1.10	<5	<5	11	11	45	40
	New York	1.09	1.10	<5	<5	17	15	55	35
	Syracuse	1.09	1.10	5	<5	12	12	40	30
N. C:	Charlotte	1.13	1.18	<5	<5	24	23	40	30
N. Dak:	Minot	1.28	1.30	10	<5	31	31	55	35
Ohio:	Cincinnati	1.11	1.16	<5	<5	13	14	25	20
	Cleveland	1.10	1.12	5	<5	13	13	35	25
Okla:	Oklahoma City	1.11	1.16	<5	<5	14	14	25	20
Ore:	Portland	1.28	1.26	<5	<5	14	12	50	40
Pa:	Philadelphia	1.08	1.12	<5	<5	13	13	35	30
	Pittsburgh	1.11	1.14	5	<5	20	17	50	35
P. R:	San Juan	1.13	1.12	<5	<5	9	10	40	35
R. I:	Providence	1.10	1.13	<5	<5	16	15	65	45
S. C:	Charleston	1.14	1.17	<5	<5	23	24	70	65
S. Dak:	Rapid City	1.04	1.23	10	<5	20	22	50	50
Tenn:	Chattanooga	1.16	1.22	<5	<5	26	23	40	35
	Memphis	1.15	1.18	5	<5	20	19	25	15
Tex:	Austin	1.12	1.17	<5	<5	5	6	20	15
	Dallas	1.11	1.16	<5	<5	12	13	25	20
Utah:	Salt Lake City	1.36	1.40	<5	<5	12	13	55	40
Vt:	Burlington	1.11	1.12	<5	<5	17	15	65	45
Va:	Norfolk	1.13	1.17	<5	<5	17	17	40	30
Wash:	Seattle	1.28	1.31	<5	<5	18	19	70	50
	Spokane	1.33	1.31	<5	<5	18	16	50	40
W. Va:	Charleston	1.12	1.17	<5	<5	18	17	25	25
Wis:	Milwaukee	1.17	1.21	<5	<5	11	13	40	40
Wyo:	Laramie	1.28	1.30	<5	<5	14	13	50	50
Network average		1.16	1.19	<5	<5	15.3	14.8	44	35

[a] All iodine-131 and barium-140 values were below detectable levels.

Table 2. Frequency distribution, strontium-90 concentrations in milk at Pastuerized Milk Network Stations, May–October 1965 and October 1964

Strontium-90 (pCi/liter)	Number of stations						
	1965						1964
	May	June	July	Aug	Sep	Oct	Oct
Under 10	4	7	8	10	11	8	6
10–19	26	21	34	41	44	46	37
20–29	25	29	18	11	7	7	13
30–39	5	4	3	1	1	2	7
40–49	2	2	0	0	0	0	0
50–59	0	0	0	0	0	0	0
60–69	1	0	0	0	0	0	0
70–79	0	0	0	0	0	0	0

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, May–October 1965 and October 1964

Cesium-137 (pCi/liter)	Number of stations						
	1965						1964
	May	June	July	Aug	Sep	Oct	Oct
Under 50	17	19	34	45	50	54	16
50–99	31	38	25	16	12	8	40
100–149	13	5	3	1	0	0	6
150–199	2	1	1	1	1	1	0
200–249	0	0	0	0	0	0	1
250–299	0	0	0	0	0	0	0

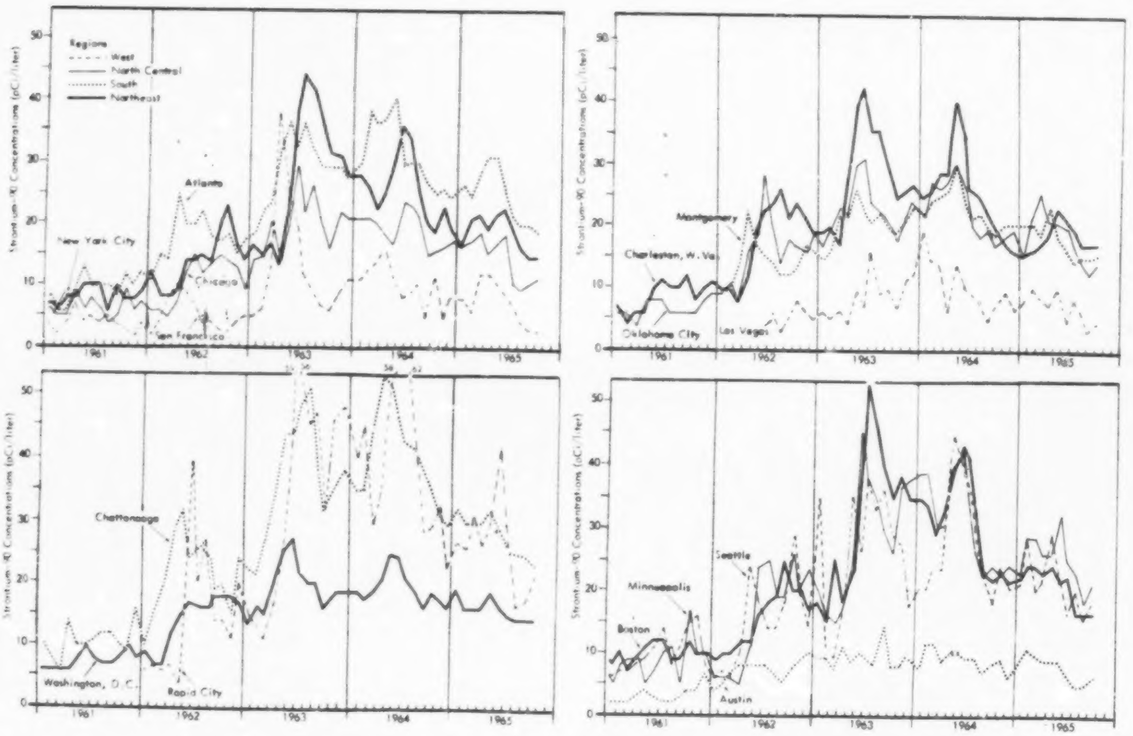

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961–October 1965

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2. Canadian Milk Network[1]
October 1965

Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine-131, and monthly composites are analyzed for strontium-90, cesium-137, and stable calcium and potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data (7)*.

The October 1965 monthly average strontium-90, cesium-137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 4. Iodine-131 and strontium-89 concentrations were below minimum detectable levels.

Table 4. Stable elements and radionuclides in Canadian whole milk, October 1965

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.15	1.4	16.7	63
Edmonton	1.14	1.4	19.8	54
Ft. William	1.12	1.6	28.1	82
Fredericton	1.12	1.6	30.8	73
Halifax	1.15	1.6	39.1	68
Montreal	1.09	1.6	16.6	42
Ottawa	1.14	1.6	13.7	38
Quebec	1.11	1.6	27.4	74
Regina	1.14	1.6	17.5	49
St. John's, Nfld	1.02	1.5	35.8	107
Saskatoon	1.14	1.6	20.1	41
Sault Ste. Marie	1.08	1.5	27.0	83
Toronto	1.13	1.6	7.6	32
Vancouver	1.20	1.6	23.0	101
Windsor	1.14	1.5	8.8	29
Winnipeg	1.08	1.6	18.4	62
Average	1.12	1.6	21.9	62

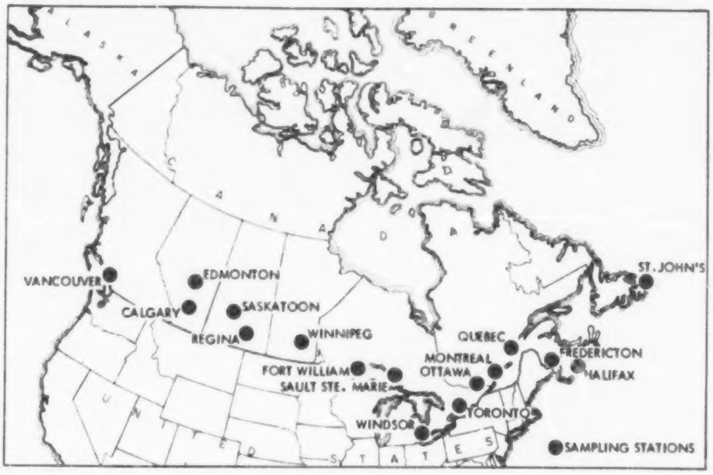

Figure 3. Canadian milk sampling stations

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[1] Prepared from November 1965 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Milk Sampling Program, October 1965

Pan American Health Organization and Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the Public Health Service (PHS), furnishes assistance to health agencies in the American republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries. Sampling locations are shown in figure 4. Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1965 issue of *Radiological Health Data (8)*.

Table 5 presents stable calcium and potassium, strontium-90, strontium-89, and cesium-137 monthly average concentrations. The monthly average iodine-131 and barium-140 concentrations in milk were less than 10 pCi/liter.

Table 5. Stable element and radionuclide concentrations in PAHO milk, October 1965

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Canal Zone:					
Cristobal	1.14	1.6	<5	5	35
Jamaica:					
Kingston	NS	NS	NS	NS	NS
Mandeville	NS	NS	NS	NS	NS
Montego Bay	NS	NS	NS	NS	NS
Puerto Rico:					
San Juan	1.12	1.6	<5	30	35
Venezuela:					
Caracas	1.23	1.45	<5	6	15

NS indicates no sample collected.

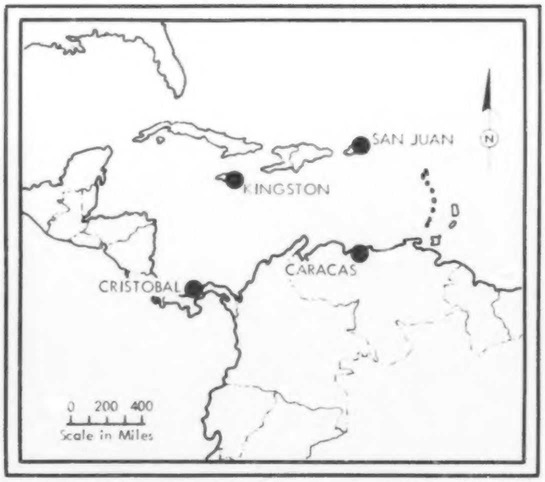

Figure 4. Pan American Milk Network sampling stations

REFERENCES

(*1*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents. U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960). Price 20 cents.

(*2*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards. Report No. 2. Superintendent of documents. U.S. Government Printing Office, Washington, D.C. 20402 (September 1961). Price 20 cents.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action guides for strontium-89, strontium-90, and cesium-137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965). Price 30 cents.

(*4*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press (1959).

(*5*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 6. Pergamon Press (1965).

(*6*) PUBLIC HEALTH SERVICE. DIVISION OF RADIOLOGICAL HEALTH AND DIVISION OF ENVIRONMENTAL ENGINEERING AND FOOD PROTECTION. Rad Health Data 6:667–681 (December 1965).

(*7*) RADIATION PROTECTION DIVISION, DEPARTMENT OF NATIONAL HEALTH AND WELFARE, OTTAWA, CANADA. Canadian Milk Network, August 1965. Rad Health Data 6:685–686 (December 1965).

(*8*) PAN AMERICAN HEALTH ORGANIZATION, and PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1965. Rad Health Data 6:687 (December 1965).

STATE MILK SURVEILLANCE ACTIVITIES

The sampling and analysis for radionuclides in milk is an integral part of comprehensive environmental surveillance programs. A number of States have developed milk surveillance programs to satisfy their needs. While there is variation between programs, to a considerable extent the data produced complements that from Federal milk surveillance activities. Data from selected State milk surveillance activities are presented below. The results presented, while not all-inclusive, are representative of current State milk surveillance activities.

1. Connecticut Milk Network
April–September 1965

Connecticut State Department of Health

The Connecticut State Department of Health has been monitoring pasteurized milk for strontium–89 and strontium–90 since April 1960. In May 1962 the program was expanded to include the determination of gamma-emitting radionuclides in milk.

The sampling program is flexible in nature, providing for sampling in five areas of the State (figure 1). At the present time, a monthly sample representative of milk sold in the central area of the State is collected and analyzed for strontium–89, strontium–90, and gamma emitters. Concentrations of iodine–131 are determined as an indication of the presence of radioactivity of recent origin.

Strontium–89 and strontium–90 are determined by chemical separation. Iodine–131 and cesium–137 are determined by gamma-scintillation spectroscopy.

The monthly average concentrations of strontium–89, strontium–90, iodine–131, and cesium–137 in Connecticut pasteurized milk are presented in table 1. These results are presented graphically in figure 2.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
April 1960–December 1962	*May 1963*
January 1963–December 1963	*September 1964*
January 1964–December 1964	*May 1965*
January 1965–March 1965	*August 1965*

Table 1. Radionuclide concentrations in central Connecticut milk, April–September 1965 [a]

Month, 1965	Concentration (pCi/liter)		
	Strontium-89	Strontium-90	Cesium-137
April	ND	15	80
May	ND	16	70
June	ND	13	40
July	ND	13	50
August	ND	14	50
September	ND	13	40

ND, below detectable levels.

[a] Iodine-131 concentrations were below detectable levels.

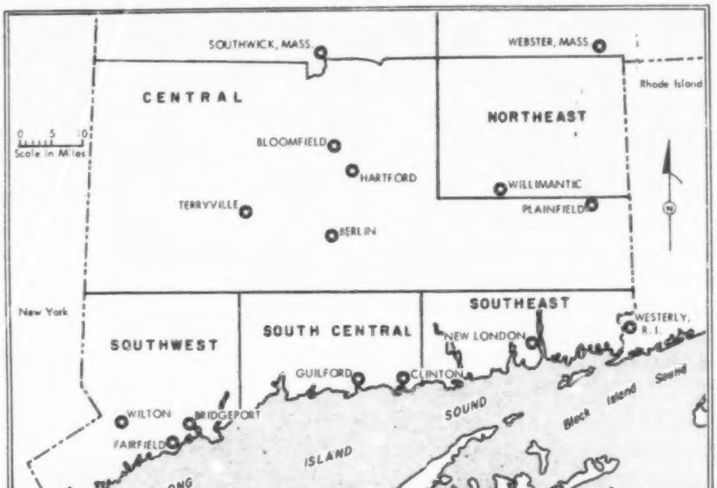
SOUTHWICK, MASS.
WEBSTER, MASS.
Rhode Island
CENTRAL
NORTHEAST
0 5 10
Scale in Miles
BLOOMFIELD
HARTFORD
WILLIMANTIC
TERRYVILLE
PLAINFIELD
BERLIN
New York
SOUTHEAST
WESTERLY, R.I.
SOUTHWEST
SOUTH CENTRAL
NEW LONDON
GUILFORD
CLINTON
WILTON
BRIDGEPORT
FAIRFIELD
SOUND
Block Island Sound
LONG ISLAND
ATLANTIC OCEAN

Figure 1. Connecticut pasteurized milk sampling areas

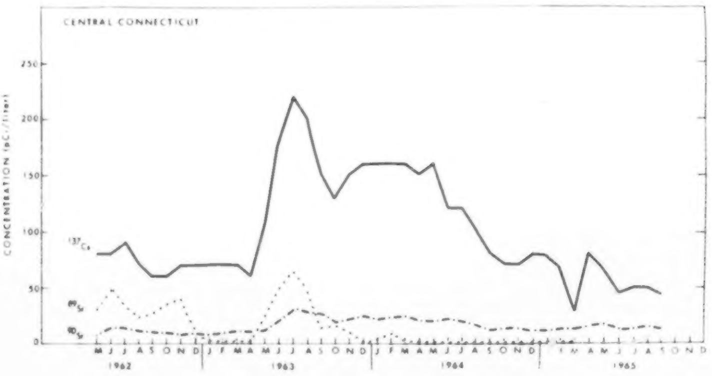

Figure 2. Radionuclide concentrations in Connecticut pasteurized milk, 1962–September 1965

2. Indiana Milk Network
July–September 1965

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radionuclide analysis in September 1961. The State was geographically divided into five major milksheds: Northeast, Northwest, Central, Southeast, and Southwest (figure 3). One large dairy within each milkshed was assumed to be representative for sampling purposes.

The milk samples are analyzed for strontium-89, strontium-90, cesium-137, iodine-131, and barium-140. Strontium-89 and strontium-90 analyses are performed monthly. Cesium-137, iodine-131, and barium-140 analyses are performed weekly. When iodine-131 concentrations exceed 100 pCi/liter, the sampling frequency is increased. Since August 1963, because of the continued low concentrations of short-lived radionuclides, the sampling frequency has been once a month for the Northeast, Southeast, and Southwest milksheds.

Strontium-89 and strontium-90 concentrations in milk samples are determined by ion exchange separation (*1,2,3*), while cesium-137, iodine-131, and barium-140 are determined by gamma scintillation spectrometry.

The monthly radionuclide concentrations in Indiana pasteurized milk are presented by station in table 2 for July through September 1965. The monthly concentrations of iodine-131 and barium-140 remained below limits of detectability.

The monthly network average concentrations of strontium-89, strontium-90, and cesium-137 are presented graphically in figure 4.

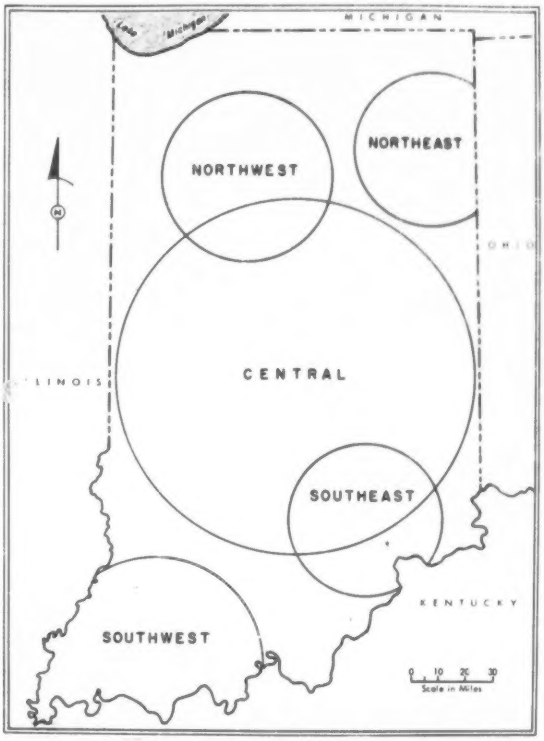

Figure 3. Indiana pasteurized milk sampling areas

Table 2. Radionuclides in Indiana milk, July–September 1965

Sampling locations	Calcium (g/liter)			Potassium-40 (pCi/liter)			Strontium-90 (pCi/liter)			Cesium-137 (pCi/liter)		
	July	Aug	Sep	July	Aug	Sep	July	Aug	Sep	July	Aug	Sep
Northeast	1.13	1.13	1.14	1,340	1,330	1,380	9	12	13	25	30	30
Southeast	1.13	NS	1.13	1,430	NS	1,410	17	NS	14	25	NS	25
Central	1.13	1.13	1.13	1,360	1,360	1,340	11	12	10	25	25	25
Southwest	1.13	1.15	1.13	1,330	1,420	1,360	14	20	16	30	20	15
Northwest	1.13	1.13	1.13	1,380	1,360	1,360	10	15	13	40	35	30
Average	1.13	1.14	1.13	1,370	1,370	1,370	12	15	13	30	30	25

NS, no sample collected.

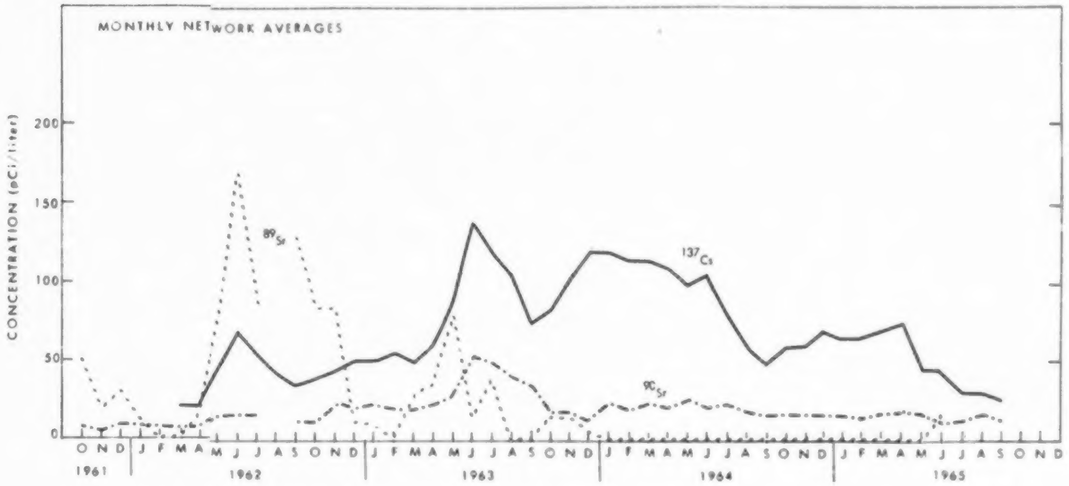

Figure 4. Radionuclide concentrations in Indiana pasteurized milk, 1961–September 1965

3. Michigan Milk Network July–September 1965

Division of Occupational Health
Michigan Department of Health

The Michigan Department of Health began sampling pasteurized milk for radionuclide analyses in November 1962. Under this program, weekly pasteurized milk samples are collected in the seven major milk producing areas in the State: Charlevoix, Detroit, Grand Rapids, Lansing, Marquette, Monroe, and Saginaw (see figure 5). Milkshed samples are composites from dairies, in proportion to sales volumes.

Strontium–90 concentrations are determined by an ion exchange method (*2*). Potassium–40, iodine–131, cesium–137, and barium–lanthanum–140 concentrations are determined by gamma scintillation spectrometry (*4*).

Table 3 presents the monthly average radionuclide concentrations in Michigan pasteurized milk. Iodine–131 and barium–lanthanum–140 were not detected during this period. Strontium–90 and cesium–137 concentrations are presented graphically in figure 6 to show general trends.

Table 3. Radionuclides in Michigan pasteurized milk[a] July–September 1965, pCi/liter

Station	Month, 1965	Potassium-40	Strontium-90	Cesium-137
Charlevoix	July	1,350	24	59
	August	1,330	17	41
	September	1,320	NA	38
Detroit	July	1,310	14	34
	August	1,320	11	27
	September	1,350	NA	24
Grand Rapids	July	1,350	19	45
	August	1,320	16	40
	September	1,330	NA	33
Lansing	July	1,340	14	39
	August	1,350	12	35
	September	1,330	NA	26
Marquette	July	1,330	29	102
	August	1,310	23	77
	September	1,290	NA	66
Monroe	July	1,380	12	23
	August	1,360	10	22
	September	1,290	NA	19
Saginaw	July	1,330	12	35
	August	1,300	9	30
	September	1,340	NA	26
Average	July	1,340	18	48
	August	1,330	14	39
	September	1,320	NA	33

NA, no analysis.

[a] All iodine-131 values were below detection limit of 14 pCi/liter and barium-lanthanum-140 results reported as 0 for this period.

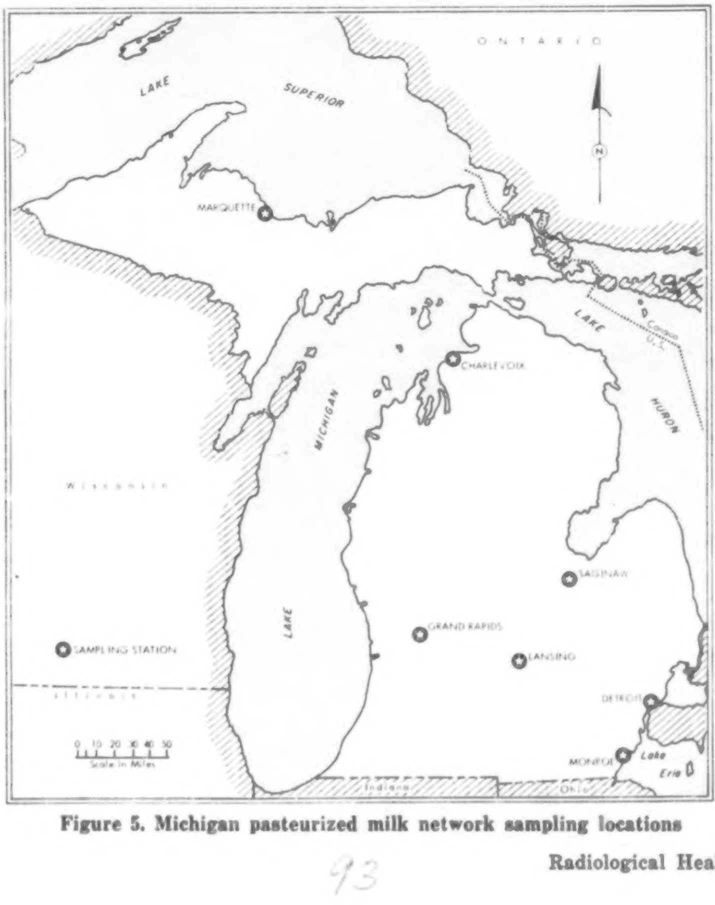
ONTARIO
LAKE SUPERIOR
N
MARQUETTE
CHARLEVOIX
LAKE HURON
Canada U.S.
LAKE MICHIGAN
WISCONSIN
SAGINAW
GRAND RAPIDS
LANSING
DETROIT
MONROE
Lake Erie
SAMPLING STATION
ILLINOIS
0 10 20 30 40 50
Scale in Miles
Indiana
Ohio

Figure 5. Michigan pasteurized milk network sampling locations

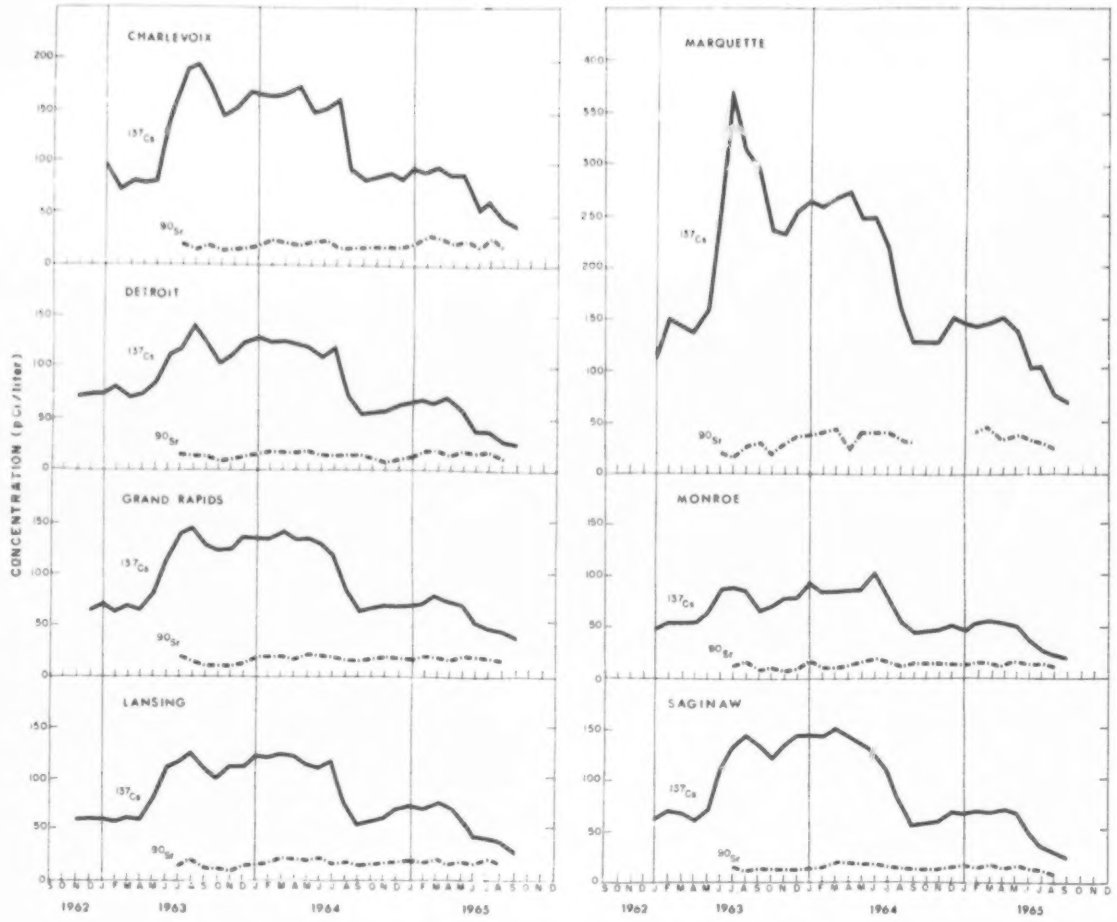

Figure 6. Radionuclide concentrations in Michigan pasteurized milk, 1962–September 1965

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
November 1962–December 1964	*September 1965*
Annual 1964	*September 1965*
January–June 1965	*November 1965*

4. Pennsylvania Milk Network July–September 1965

Bureau of Environmental Health
Pennsylvania Department of Health

Samples of pasteurized milk are routinely collected from 10 major milk consumption areas throughout Pennsylvania (figure 7). Two samples per week are collected in Philadelphia and Pittsburgh, while weekly composite samples are collected from the other eight stations. At each sampling location sub-samples are collected from the major dairies supplying the area and are composited in proportion to the amount of milk processed by each dairy. This composite is then sent to the Radiation Laboratory of the Division of Occupational Health in Harrisburg where the weekly samples are combined for monthly analyses. Strontium–90 analyses have been carried out since April 1963.

The chemical separation technique for strontium–90 is essentially an ion exchange method described by Porter *et al.* (*2*).

The monthly average potassium–40, strontium–90, and cesium–137 concentrations in pasteurized milk are given in table 4. Iodine–131 concentrations were all below the detection limit of 10 pCi/liter. For comparative purposes, strontium–90, iodine–131, and cesium–137 concentration are presented graphically in figure 8.

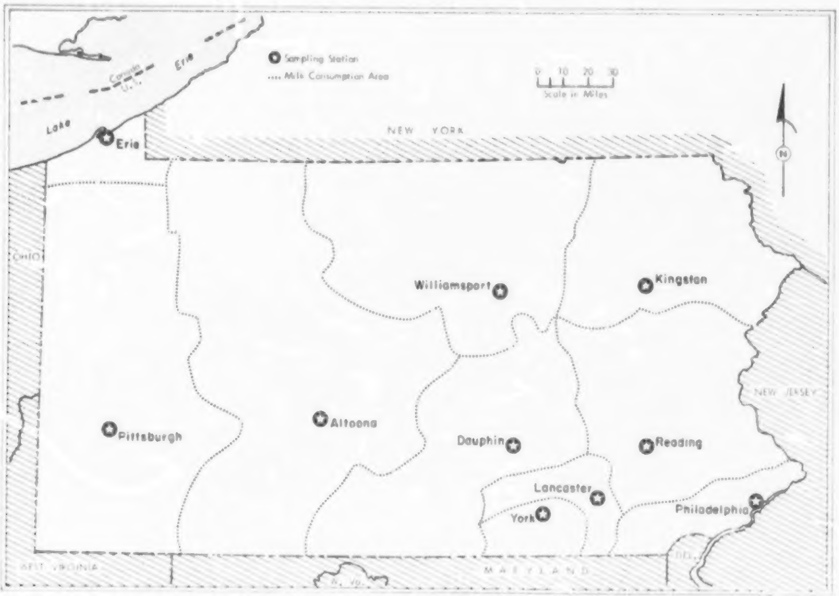
Sampling Station
.... Milk Consumption Area
0 10 20 30
Scale in Miles
N
Lake
Erie
Canada
U.S.
NEW YORK
OHIO
NEW JERSEY
WEST VIRGINIA
W. Va.
MARYLAND
DEL.
Erie
Williamsport
Kingston
Pittsburgh
Altoona
Dauphin
Reading
Lancaster
York
Philadelphia

Figure 7. Pennsylvania pasteurized milk network sampling locations

Table 4. Potassium-40, strontium-90, and cesium-137 concentrations [a] in Pennsylvania milk, July–September 1965

Sampling locations	Radionuclide concentrations, pCi/liter								
	Potassium-40			Strontium-90			Cesium-137		
	Jul	Aug	Sep	Jul	Aug	Sep	Jul	Aug	Sep
Altoona	1,010	1,040	990	13	14	14	72	59	55
Dauphin	990	1,050	980	9	8	12	73	72	53
Erie	1,060	1,000	1,130	16	13	18	102	91	72
Kingston	970	1,080	970	17	15	19	92	74	65
Lancaster	1,070	960	975	10	9	12	72	61	54
Philadelphia	1,080	1,060	1,015	11	11	15	74	66	57
Pittsburgh	970	1,030	980	19	15	18	88	77	61
Reading	1,025	1,020	980	10	15	12	76	68	56
Williamsport	1,050	1,030	1,025	12	12	12	101	75	68
York	1,000	1,050	1,110	11	13	13	70	63	66
Average	1,020	1,030	1,020	13	13	15	82	71	61

[a] All iodine-131 concentrations for this period were <10.

95

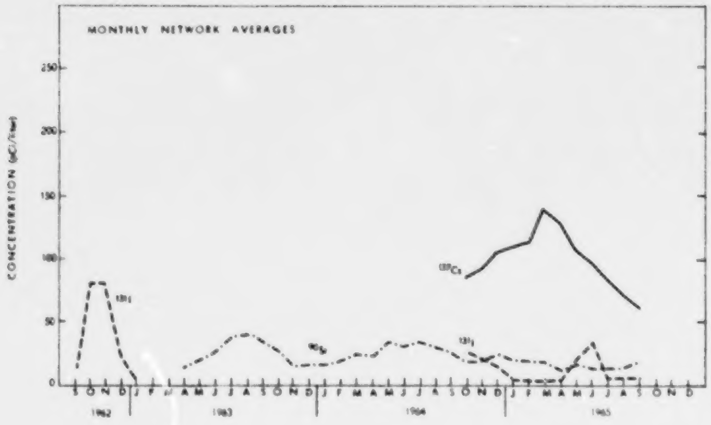

Figure 8. Radionuclide concentrations in Pennsylvania pasteurized milk, 1962–September 1965

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
September 1962–November 1963	*March 1964*
December 1963–March 1964	*July 1964*
April–June 1964	*October 1964*
August–September 1964	*February 1965*
Annual 1964	*June 1965*
January–March 1965	*September 1965*
April–June 1965	*November 1965*

REFERENCES

(*1*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Determination of strontium-90 in milk by an ion-exchange method. Anal Chem 33:1306–1308 (September 1961).

(*2*) PORTER, C., D. CAHILL, R. SCHNEIDER, P. ROBBINS, W. PERRY, and B. KAHN. Improved determination of strontium-90 in milk by an ion exchange method. Anal Chem 36:676–678 (March 1964).

(*3*) BUREAU OF ENVIRONMENTAL SANITATION, INDIANA STATE BOARD OF HEALTH. Indiana Milk Network, April–June 1965. Rad Health Data 6:612–614 (November 1965).

(*4*) MICHIGAN DEPARTMENT OF HEALTH. Michigan Milk Network, November 1962—December December 1964. Rad Health Data 6:487–492 (September 1965).

Other State coverage in *Radiological Health Data and Reports:*

Program	Period Reported	Last Presented
California Milk Network	April–June 1965	*December 1965*
Colorado Milk Network	October–December 1964	*April 1965*
Florida Milk Network	July–December 1964	*January 1966*
Minnesota Milk Network	July–December 1964	*January 1966*
Oklahoma Milk Network	March–July 1965	*October 1965*
Oregon Milk Network	January–March 1965	*August 1965*
New York Milk Network	January–March 1965	*January 1966*
Texas Milk Network	January–March 1965	*October 1965*
Washington Milk Network	January–March 1965	*November 1965*

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. While not based on probability sampling, these networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides.

RADIONUCLIDES IN INSTITUTIONAL DIET SAMPLES, APRIL-JUNE 1965

Division of Radiological Health
Public Health Service

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiation surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Diet Sampling Program in 1961. This program is conducted by the Division of Radiological Health with the assistance of the Division of Environmental Engineering and Food Protection (*1*).

The program is designed to estimate the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially the program consisted of sampling at eight institutions; as of January 1965, sampling had increased to boarding schools or institutions in 50 municipalities, distributed as shown in figure 1. These institutions range from financially well-to-do boarding schools to orphanages with severe economic limitations. Each institution (with the exception of those at Los Angeles, California; Fargo, North Dakota; Columbia, Mississippi; Carson City, Nevada; and Sioux Falls, South Dakota) is located in a community from which the PHS Pasteurized Milk Network

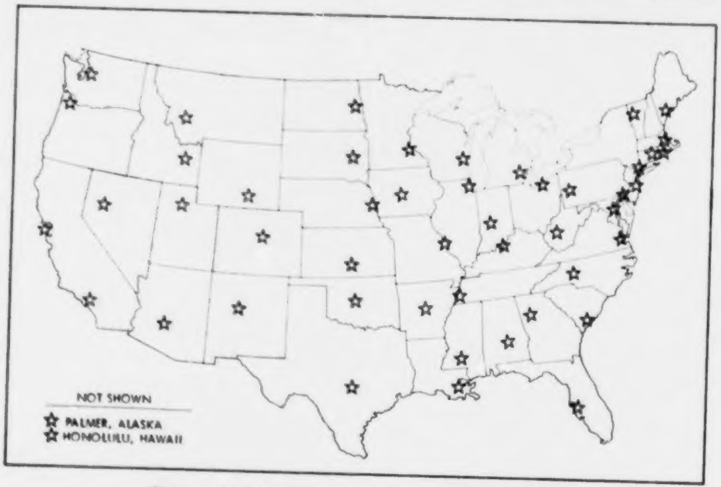

Figure 1. Institutional diet sampling locations

(PMN) collects samples. In those communities not sampled by the PMN, special milk samples are collected which supplement the findings for the Institutional Diet Sampling Program.

In general, the sampling procedure is the same at each institution. Each sample supplied by each institution monthly represents the edible portion of the diet for a full 7-day week (21 meals, plus soft drinks, candy bars, or other in-between snacks), obtained by duplicating the meals of a different individual each day. Drinking water is not included in the samples but is sampled periodically. Each daily sample is kept frozen until the end of the collection period, and is then packed in dry ice and shipped by air express to either the Southwestern Radiological Health Laboratory, Las Vegas, Nevada; the Southeastern Radiological Health Laboratory, Montgomery, Alabama; or the Northeastern Radiological Health Laboratory, Winchester, Masachusetts. A detailed description of sampling and analytical procedures is presented elsewhere (*2*).

Results

Table 1 gives the analytical results for institutional diet samples collected from April through June 1965. Stable elements are reported in g/kg of diet, and radionuclide concentrations are expressed as pCi/kg of diet. A maximum of 51 institutions in 50 municipalities participated in this sampling program during this period.

When discussing intake on a per-day basis, it is meaningful to delineate differences resulting from age and sex. In an effort to evaluate these differences, table 2 presents the dietary intake of teenage boys (13 to 18 years of age) on a per-day basis. The intake values were obtained by multiplying the food consumption rate in kg/day times the concentration values given in table 1. The reported radionuclide concentrations of these samples are corrected for radioactive decay to the midpoint of the sample collection period where applicable.

Certain of the radionuclide concentration results have been reported as being "less than" (<) a specified value. For purposes of data computations to obtain dietary intakes, "less than" 10 pCi/kg values for iodine-131 and barium-140 were interpreted as zero and "less than" 5 pCi/kg of strontium-89 as 2.5 pCi/kg.

Table 3 presents the daily dietary intake of teenage girls (13 to 18 years of age). Table 4 presents the daily dietary intake of children 9 to 12 years of age.

A summary of these results (table 5) shows a variation between age groups. Teenage girls and younger children have comparable intakes, while teenage boys consistently have higher intakes by about 20 percent. These values are comparable with the network average of 1.90 kg/day observed from 1961 to 1964 (*3*).

Where strontium-89 dietary intake remained below detectable levels, the strontium-90 dietary intake during this period remained fairly constant at approximately 27 pCi/day. These results fall within Range II as defined by the Federal Radiation Council (*4*). While the Radiation Protection Guides (RPG's) and related intake ranges were developed for controlling normal peacetime operations, nevertheless, annual radiation doses from fallout equal to or greater than the RPG's can be used to indicate a need to initiate an evaluation of fallout exposures. The current strontium-90 levels indicate that surveillance must be adequate to provide estimates of the probable variations in average daily intake in time and location.

Cesium-137 intakes were observed to steadily decrease during this period following the peak observed in 1964 (*3*). During this period, both barium-140 and iodine-131 concentrations were below detectable levels.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July-September 1963	*March 1964*
October-December 1963	*July 1964*
January-March 1964	*October 1964*
April-June 1964	*January 1965*
July-September 1964	*April 1965*
October-December 1964	*July 1965*
1964 Annual Averages	*July 1965*
January-March 1965	*October 1965*

REFERENCES

(*1*) ANDERSON, E. C., and D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391-1400 (September 1962).

(*2*) DIVISION OF RADIOLOGICAL HEALTH, PUBLIC HEALTH SERVICE. Radionuclides in institutional total diet samples, January-March 1965. Rad Health Data 6:548-554 (October 1965).

(*3*) GRUNDY, R. D., C. CALVERT, and A. G. BERGER. Summary of results of Institutional Total Diet Sampling Network, 1961-1964. Rad Health Data 6:691-698 (December 1965).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961). Price 20 cents.

Table 1. Institutional diet analytical results, all schools, second quarter 1965

Location of institution		Month (1965)	Stable elements, g/kg		Radionuclide concentrations, pCi/kg			
			Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Ala:	Montgomery	Apr	0.6	1.0	<5	12	25	NA
		May	0.6	1.1	<5	14	50	NA
		June	0.5	1.0	<5	10	25	NA
Alaska:	Palmer	Apr	0.6	1.2	<5	15	70	0.3
		May	0.6	1.2	<5	27	60	0.5
		June	0.8	1.6	<5	21	70	0.5
Ariz:	Phoenix	Apr	0.7	1.4	<5	18	45	0.5
		May	0.8	1.7	<5	19	60	0.5
		June	0.7	1.3	<5	11	30	0.6
Ark:	Little Rock	Apr	0.8	1.0	<5	28	40	NA
		May	0.7	1.5	<5	24	45	NA
		June	0.6	1.2	<5	19	30	NA
Calif:	Los Angeles	Apr	0.8	1.6	<5	5	25	0.8
		May	0.6	1.3	<5	7	30	0.5
		June	0.6	1.5	<5	7	30	0.4
	San Francisco [a]	Apr	0.6	1.4	<5	11	30	0.3
		May	0.7	1.4	<5	18	35	0.5
		June	0.6	2.0	<5	9	40	0.8
Colo:	Denver	Apr	0.8	1.6	<5	17	85	0.7
		May	0.6	1.3	<5	12	35	0.7
		June	0.7	1.5	<5	17	65	0.6
Conn:	Hartford	Apr	0.7	1.8	<5	9	80	0.7
		May	0.7	1.8	<5	11	80	0.5
		June	0.8	1.5	5	12	50	0.6
Del:	Wilmington	Apr	0.8	1.6	<5	12	55	0.8
		May	0.8	1.6	<5	12	55	0.7
		June	0.8	1.6	<5	14	55	0.8
Fla:	Tampa	Apr	0.7	1.5	<5	16	100	NA
		May	0.6	2.0	<5	11	105	NA
		June	0.9	1.5	<5	12	110	NA
Ga:	Atlanta	Apr	0.6	1.4	<5	18	75	NA
		May	0.5	1.6	<5	19	50	NA
		June	0.6	1.5	<5	18	45	NA
Hawaii:	Honolulu	Apr	0.5	1.1	<5	12	35	1.0
		May	0.7	1.2	<5	14	35	1.2
		June	0.6	1.2	<5	23	25	0.7
Idaho:	Idaho Falls	Apr	0.7	1.6	<5	27	120	0.5
		May	0.7	1.6	<5	29	85	0.6
		June	0.6	1.5	<5	20	55	0.6
Ill:	Chicago	Apr	0.7	1.4	<5	9	70	0.5
		May	0.8	1.7	<5	13	75	0.7
		June	0.6	1.6	<5	11	60	0.5
Ind:	Indianapolis	Apr	0.9	1.4	<5	14	65	0.8
		May	0.8	1.4	5	13	55	0.4
		June	0.8	1.5	15	12	40	0.8
Iowa:	Des Moines	Apr	0.7	1.6	<5	17	60	NA
		May	0.7	1.6	<5	15	70	NA
		June	0.4	1.1	<5	12	30	NA
Kans:	Wichita	Apr	0.8	1.6	<5	19	50	NA
		May	0.7	1.4	<5	12	40	NA
		June	0.8	1.6	<5	12	40	NA
Ky:	Louisville	Apr	0.5	1.1	<5	15	35	NA
		May	0.5	0.9	<5	13	25	NA
		June	0.6	1.3	<5	16	30	NA
La:	New Orleans	Apr	0.6	1.6	<5	19	55	NA
		May	0.6	1.3	<5	18	50	NA
		June	0.6	1.2	<5	19	40	NA
Maine:	Portland	Apr	0.8	1.5	<5	12	85	0.5
		May	0.8	1.4	<5	15	95	0.8
		June	0.8	1.4	<5	17	70	0.6
Md:	Baltimore	Apr	0.6	1.6	<5	14	45	NA
		May	0.7	1.5	<5	17	60	NA
		June	0.7	1.4	<5	18	50	NA
Mass:	Boston A [b]	Apr	0.6	1.5	<5	11	65	0.8
		May	0.6	1.4	5	9	95	0.4
		June	0.7	1.3	5	14	65	0.5
	Boston B [b]	Apr	0.5	1.3	<5	9	50	0.6
		May	0.6	1.4	<5	7	40	0.5
		June	0.5	1.2	<5	6	45	0.4
Mich:	Detroit	Apr	0.9	1.6	<5	12	75	0.9
		May	0.7	1.3	<5	8	70	0.7
		June	0.7	1.6	<5	7	55	0.8
Minn:	Minneapolis	Apr	0.9	1.8	<5	17	45	1.1
		May	0.7	1.6	<5	24	80	0.6
		June	0.6	1.4	<5	19	60	0.7
Miss:	Columbia	Apr	0.8	1.4	<5	23	75	NA
		May	0.8	1.4	<5	22	70	NA
		June	0.8	1.6	<5	18	60	NA
Mo:	St. Louis	Apr	0.8	1.0	<5	15	30	0.8
		May	0.7	1.7	<5	25	30	1.2
		June	0.7	1.5	<5	16	25	0.7

Table 1. Institutional diet analytical results, all schools, first quarter 1965—Continued

Location of institution		Month (1965)	Stable elements, g/kg		Radionuclide concentrations, pCi/kg			
			Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Mont:	Helena	Apr May June	0.5 0.4 0.4	1.4 1.3 0.9	<5 <5 <5	12 13 7	60 45 30	1.2 0.6 0.4
Nebr:	Omaha	Apr May June	0.9 0.7 0.7	1.6 1.3 1.5	<5 <5 <5	22 20 16	75 55 60	0.9 0.7 0.5
Nev:	Carson City	Apr May June	0.8 0.7 0.8	1.4 1.1 1.5	<5 <5 <5	9 7 11	55 35 45	0.5 0.6 0.3
N. J:	Trenton	Apr May June	0.5 0.8 0.8	1.4 1.4 1.1	<5 <5 <5	10 13 18	65 45 50	0.7 0.5 1.4
N. Mex:	Albuquerque	Apr May June	0.8 0.8 0.8	1.3 1.6 1.6	<5 <5 <5	10 13 14	30 45 25	0.7 0.7 0.5
N. Y:	New York	Apr May June	1.0 0.7 NS	1.6 1.4 NS	<5 <5 NS	12 18 NS	75 70 NS	0.7 1.0 NS
N. C:	Charlotte	Apr May June	0.6 0.6 0.6	1.2 0.9 1.1	<5 <5 <5	13 17 14	50 50 20	NA NA NA
N. Dak:	Fargo	Apr May June	0.8 0.6 0.7	1.6 1.3 1.4	<5 <5 10	13 15 16	80 65 60	0.4 0.3 0.7
Ohio:	Cleveland	Apr May June	0.6 0.7 0.7	1.7 1.7 1.7	<5 <5 10	15 10 11	65 55 75	0.5 0.7 0.7
Okla:	Oklahoma City	Apr May June	0.6 0.7 0.5	1.4 1.5 1.1	<5 <5 <5	12 12 10	30 35 20	NA NA NA
Ore:	Portland	Apr May June	0.6 0.6 0.5	1.7 1.5 1.4	<5 <5 <5	9 17 14	60 60 55	NA 0.6 0.5
Pa:	Pittsburgh	Apr May June	0.6 0.4 0.6	1.5 1.3 1.3	<5 <5 5	14 13 16	70 60 60	0.6 0.4 1.1
R. I:	Providence	Apr May June	0.8 0.8 0.8	1.5 1.6 1.5	<5 <5 5	12 8 13	85 80 60	0.3 0.6 0.6
S. C:	Charleston	Apr May June	0.7 0.8 0.6	1.4 1.5 1.1	<5 <5 <5	19 21 14	65 75 50	NA NA NA
S. Dak:	Sioux Falls	Apr May June	0.7 0.8 0.8	1.6 1.6 1.7	15 <5 5	8 15 22	70 70 75	0.4 0.9 0.7
Tenn:	Memphis	Apr May June	0.7 0.6 0.6	1.6 1.4 1.4	<5 <5 <5	22 17 16	45 35 40	NA NA NA
Tex:	Austin	Apr May June	0.4 0.4 0.4	1.0 1.3 1.0	<5 <5 <5	8 8 6	25 20 30	NA NA NA
Utah:	Salt Lake City	Apr May June	0.6 0.7 0.5	1.6 1.4 1.5	<5 <5 <5	13 18 15	75 45 75	0.5 0.8 0.4
Vt:	Burlington	Apr May June	0.7 1.0 1.0	1.7 1.6 1.5	<5 <5 <5	14 16 16	95 100 60	0.7 0.3 0.9
Va:	Norfolk	Apr May June	0.5 0.5 0.5	1.2 1.4 1.0	<5 <5 <5	14 21 14	55 45 35	NA NA NA
Wash:	Seattle	Apr May June	0.8 0.7 0.5	1.6 1.5 1.5	<5 <5 <5	19 34 18	65 75 70	0.2 0.5 0.4
W. Va:	Charleston	Apr May June	0.8 0.8 0.7	1.4 1.5 1.6	<5 <5 <5	23 19 18	60 45 45	NA NA NA
Wis:	Milwaukee	Apr May June	0.6 0.6 0.7	1.5 1.6 1.7	<5 <5 5	11 10 11	75 70 55	0.6 0.9 0.8
Wyo:	Laramie	Apr May June	0.7 0.7 0.5	1.5 1.7 1.6	<5 <5 <5	13 18 19	65 50 75	0.5 1.2 0.9
Institution average		Apr May June	0.7 0.7 0.7	1.5 1.4 1.4	<5 <5 <5	14 16 14	60 55 50	0.6 0.7 0.6

[a] Institution became part of network in April 1965.
[b] "A" and "B" denote two separate institutions in Boston.
NA, no analysis.
NS, no samples

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Table 2. Institutional diet daily intakes, teenage boys, second quarter 1965

Location of institution	Age (yrs)	Month 1965	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
				Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Ala: Montgomery	15-17	Apr	2.17	1.3	3.5	5	26	55	NA
	15-17	May	2.25	1.4	2.5	5	32	110	NA
	15-17	June	2.15	1.1	2.2	5	22	55	NA
Hawaii: Honolulu	14-17	Apr	1.91	1.0	2.1	5	23	65	1.9
	15-17	May	1.90	1.3	2.3	5	27	65	2.3
	14-17	June	1.97	1.2	2.4	5	45	50	1.4
Idaho: Idaho Falls	17	Apr	1.82	1.3	2.9	5	49	220	0.9
	17	May	1.94	1.4	3.1	5	56	165	1.2
	17	June	1.91	1.1	2.9	5	38	105	1.1
Iowa: Des Moines	13-16	Apr	2.59	1.8	4.1	5	44	155	NA
	14-15	May	3.19	2.2	5.1	10	48	225	NA
	13-16	June	1.89	0.8	2.1	5	23	55	NA
Ky: Louisville	15-16	Apr	1.80	0.9	2.0	5	32	65	NA
	15-16	May	1.99	1.0	1.8	5	26	50	NA
	15-17	June	1.61	1.0	2.1	5	21	50	NA
Maine: Portland	14	Apr	2.34	1.9	3.5	5	28	200	1.2
	14	May	2.36	1.9	3.3	5	35	225	1.9
	14	June	2.25	1.8	3.2	5	38	160	1.4
Minn: Minneapolis	13-16	Apr	2.18	2.0	3.9	5	37	100	2.4
	14-15	May	1.86	1.3	3.0	5	45	150	1.1
	15-17	June	2.05	1.2	2.9	5	39	125	1.4
Miss: Columbia	15-17	Apr	2.29	1.8	3.2	5	53	170	NA
	15-17	May	2.38	1.9	3.3	5	52	165	NA
	15-17	June	1.99	1.6	3.2	5	36	120	NA
Mo: St. Louis	15-17	Apr	2.79	2.2	2.8	5	42	85	2.2
	15-17	May	2.50	1.8	4.2	5	62	75	3.0
	15-17	June	2.19	1.5	3.3	5	35	55	1.5
Nebr: Omaha	16-18	Apr	1.94	1.7	3.1	5	43	145	1.7
	15-17	May	1.84	1.3	2.4	5	35	100	1.3
	15-16	June	1.91	1.4	2.9	5	31	120	1.0
N. J: Trenton	15-17	Apr	2.35	1.2	3.3	5	24	155	1.6
	14-17	May	2.47	2.0	3.5	5	32	110	1.2
	16-17	June	1.71	1.4	1.9	5	31	85	2.4
Ore: Portland	15-17	Apr	2.40	1.4	4.1	5	22	145	NA
	15-17	May	2.30	1.4	3.4	5	39	140	1.4
	12-17	June	2.44	1.2	3.4	5	34	135	1.2
Pa: Pittsburgh	14-17	Apr	2.40	1.4	3.6	5	34	170	1.4
	14-17	May	2.35	0.9	3.1	5	31	140	0.9
	14-16	June	2.37	1.4	3.1	10	38	140	2.6
R. I: Providence	13-15	Apr	2.71	2.2	4.1	5	33	230	0.8
	13-15	May	2.74	2.2	4.4	5	22	220	1.6
	13-15	June	2.31	1.8	3.5	10	30	140	1.4
Tex: Austin	15-18	Apr	1.92	0.8	1.9	5	15	50	NA
	15-17	May	1.94	0.8	2.5	5	16	40	NA
	15-17	June	1.99	0.8	2.0	5	12	60	NA
Va: Norfolk	15-17	Apr	2.34	1.2	2.8	5	33	130	NA
	15-17	May	2.31	1.2	3.2	5	49	105	NA
	15-17	June	2.29	1.1	2.3	5	32	80	NA
Wis: Milwaukee	15-16	Apr	2.14	1.3	3.2	5	24	160	1.3
	15-18	May	2.06	1.2	3.3	5	21	145	1.9
	15-18	June	1.90	1.3	3.2	10	21	105	1.5

NA, no analysis.

Table 3. Institutional diet daily intakes, teenage girls, second quarter 1965

Location of institution	Age (yrs)	Month 1965	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
				Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Calif: San Francisco	15	Apr	1.98	1.2	2.8	5	22	60	0.6
	15	May	1.52	1.1	2.1	5	27	55	0.8
	15	June	1.59	1.0	3.2	5	14	65	1.3
Conn: Hartford	13-20	Apr	1.80	1.3	2.9	5	16	145	1.3
	15	May	1.79	1.3	3.2	5	20	145	0.9
	14-16	June	1.84	1.5	2.8	10	22	90	1.1
Ga: Atlanta	9-11	Apr [a]	1.64	1.0	2.3	5	30	125	NA
	9-12	May [a]	1.79	0.9	2.9	5	34	90	NA
	12-11	June [b]	1.65	1.0	2.5	5	30	75	NA
La: New Orleans	15-17	Apr	2.63	1.6	4.2	5	50	145	NA
	13-17	May	2.56	1.5	3.3	5	45	130	NA
	13-17	June	2.34	1.4	2.8	5	44	95	NA

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Table 3. Institutional diet daily intakes, teenage girls, second quarter 1965—Continued

Location of institution		Age (yrs)	Month 1965	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
					Calcium	Potassium	Strontium89-	Strontium-90	Cesium-137	Radium-226
Mont:	Helena	15-17	Apr	1.38	0.7	1.9	5	17	85	1.7
		16-18	May	1.16	0.5	1.5	5	15	50	0.7
		13-16	June	1.17	0.5	1.1	5	8	35	0.5
N. Y:	New York	10-12	Apr [a]	2.24	2.2	3.6	5	27	170	1.6
		10-12	May [a]	2.39	1.7	3.3	5	43	165	2.4
		NS	June	NS	NS	NS	NS	NS	NS	NS
N. C:	Charlotte	15-17	Apr	1.16	0.7	1.4	5	15	60	NA
		15-17	May	1.55	0.9	1.4	5	26	80	NA
		15-17	June	1.37	0.8	1.5	5	19	25	NA
Tenn:	Memphis	15-18	Apr	1.68	1.2	2.7	5	37	75	NA
		15-17	May	1.69	1.0	2.4	5	29	60	NA
		15-19	June	1.83	1.1	2.6	5	29	75	NA
Utah:	Salt Lake City	16-17	Apr	1.18	0.7	1.9	5	15	90	0.6
		16-17	May	1.10	0.8	1.5	5	20	50	0.9
		15-17	June	1.56	0.8	2.3	5	23	115	0.6
Wash:	Seattle	15-17	Apr	2.04	1.6	3.3	5	39	135	0.4
		15-18	May	2.04	1.4	3.1	5	69	155	1.0
		15-17	June	1.84	0.9	2.8	5	33	130	0.7

[a] Data for these months were not used in the average because food samples were collected from boys as well as girls.
[b] Data for this month were not used in average because food samples were collected from two or more children who were less than 13 years of age.
NS, no sample.
NA, no analysis.

Table 4. Institutional diet daily intakes, children (9–12 years), second quarter 1965

Location of institution		Age (yrs)	Month 1965	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
					Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Alaska:	Palmer	10-12	Apr	1.67	1.0	2.0	5	25	115	0.5
		10-12	May	1.56	0.9	1.9	5	42	95	0.8
		10-12	June	1.56	1.2	2.5	5	33	110	0.8
Ariz:	Phoenix	12-13	Apr [a]	1.60	1.1	2.2	5	29	70	0.8
		12-13	May [a]	1.77	1.4	2.0	5	34	105	0.9
		9-12	June	1.90	1.3	2.5	5	21	55	1.1
Ark:	Little Rock	11-12	Apr	1.96	1.6	2.0	5	55	80	NA
		10-12	May	1.86	1.3	2.8	5	45	85	NA
		10-12	June	1.99	1.2	2.4	5	38	60	NA
Calif:	Los Angeles	10-13	Apr	1.68	1.3	2.7	5	8	40	1.3
		11-13	May [a]	1.96	1.2	2.5	5	14	60	1.0
		11-14	June [a]	1.64	1.0	2.5	5	11	50	0.7
Colo:	Denver	11-13	Apr	2.48	2.0	4.0	5	42	210	1.7
		10-15	May [a]	2.42	1.5	3.1	5	29	85	1.7
		10-12	June	1.88	1.3	2.8	5	32	120	1.1
Del:	Wilmington	10-12	Apr	1.85	1.5	3.0	5	22	100	1.5
		10-12	May	1.78	1.4	2.8	5	21	100	1.2
		10-12	June	1.72	1.4	2.8	5	24	95	1.4
Fla:	Tampa	10-11	Apr	2.12	1.5	3.2	5	34	210	NA
		10-12	May	2.06	1.2	4.1	5	23	215	NA
		10-12	June	2.25	2.0	3.4	5	27	250	NA
Ill:	Chicago	11-12	Apr	1.30	10.8	1.8	5	12	90	0.6
		11-12	May	1.56	1.2	2.7	5	20	120	1.1
		11-12	June	1.21	0.7	1.9	5	13	75	0.6
Ind:	Indianapolis	11-12	Apr	1.56	1.4	2.2	5	22	100	1.2
		10-12	May	1.54	1.2	2.2	10	20	85	0.6
		10-12	June	1.54	1.2	2.3	25	18	60	1.2
Kans:	Wichita	10-12	Apr	1.85	1.5	3.0	5	35	90	NA
		11-16	May [a]	1.93	1.4	2.7	5	23	75	NA
		10-12	June	1.98	1.6	3.2	5	24	80	NA
Md:	Baltimore	10-12	Apr	1.64	1.0	2.6	5	23	75	NA
		10-12	May	1.78	1.2	2.7	5	30	105	NA
		10-12	June	1.88	1.3	2.6	5	34	95	NA
Mass:	Boston A	10-12	Apr	2.65	1.6	4.0	5	29	170	2.1
		10-12	May	2.42	1.5	3.4	10	22	230	1.0
		11-12	June	2.29	1.6	3.0	10	32	150	1.1
	Boston B	10-12	Apr	2.27	1.1	3.0	5	20	115	1.4
		10-12	May	2.17	1.3	3.0	5	15	85	1.1
		10-12	June	2.53	1.3	3.0	5	15	115	1.0

Table 4. Institutional diet daily intakes, children (9–12 years), second quarter 1965—Continued

Location of institution		Age (yrs)	Month 1965	Total weight (kg/day)	Stable elements, g/day		Radionuclide intakes, pCi/day			
					Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
Mich:	Detroit	11–12	Apr	2.09	1.9	3.3	5	25	155	1.9
		11–12	May	1.84	1.3	2.4	5	15	130	1.3
		10–12	June	1.83	1.3	2.9	5	13	100	1.5
Nev:	Carson City	10–12	Apr	1.30	1.2	2.1	5	14	80	0.8
		10–12	May	1.28	0.9	1.4	5	9	45	0.8
		10–12	June	1.90	1.5	2.8	5	21	85	0.6
N. Mex:	Albuquerque	10–12	Apr	2.16	1.7	2.8	5	22	65	1.5
		10–12	May	2.13	1.7	3.4	5	28	95	1.5
		10–12	June	1.99	1.6	3.2	5	28	50	1.0
N. Dak:	Fargo	10–12	Apr	1.58	1.3	2.5	5	20	125	0.6
		9–12	May	1.56	0.9	2.0	5	23	100	0.5
		10–12	June	1.09	0.8	1.5	10	17	65	0.8
Ohio:	Cleveland	10–11	Apr	1.45	0.9	2.5	5	22	95	0.7
		11–12	May	1.30	0.9	2.2	5	13	70	0.9
		10–11	June	1.45	1.0	2.5	15	16	110	1.0
Okla:	Oklahoma City	11–14	Apr *	1.76	1.1	2.5	5	21	55	NA
		10–12	May	1.69	1.2	2.5	5	20	60	NA
		10–12	June	1.91	1.0	2.1	5	19	40	NA
S. C:	Charleston	11–12	Apr	2.15	1.5	3.0	5	41	140	NA
		11–12	May	1.35	1.1	2.0	5	28	100	NA
		10–12	June	1.80	1.1	2.1	5	26	95	NA
S. Dak:	Sioux Falls	11	Apr	1.91	1.3	3.1	30	15	135	0.8
		11–12	May	1.74	1.4	2.8	5	26	120	1.6
		10–11	June	1.76	1.4	3.0	10	39	130	1.2
Vt:	Burlington	10–12	Apr	1.37	1.0	2.3	5	19	130	1.0
		10–12	May	1.42	1.4	2.3	5	23	140	0.4
		10–12	June	1.32	1.3	2.0	5	21	80	1.2
W. Va:	Charleston	10–12	Apr	1.61	1.3	2.3	5	37	95	NA
		10–12	May	1.55	1.2	2.3	5	29	70	NA
		10–11	June	1.57	1.1	2.5	5	28	70	NA
Wyo:	Laramie	11	Apr	1.89	1.3	2.8	5	25	125	0.9
		11	May	1.59	1.1	2.7	5	29	80	1.9
		11	June	1.58	0.8	2.5	5	30	120	1.4

* Data for these months were not used in average because food samples were collected from two or more children who were over 12 years of age.
NA, no analysis.

Table 5. Summary of ITDSN intake for April through June 1965 [a]

Sampling groups	Month 1965	Number of institutions	Intakes						
			Weight (kg/day)	Calcium	Potassium	Strontium-89	Strontium-90	Cesium-137	Radium-226
				(grams/day)		(picocuries/day)			
Teenage boys	April	17	2.24	1.5	3.2	5	33	135	1.5
	May	17	2.26	1.5	3.2	5	37	130	1.6
	June	17	2.06	1.3	2.7	5	31	95	1.5
Teenage girls	April	8	1.73	1.0	2.6	5	26	100	0.9
	May	8	1.68	1.1	2.3	5	31	90	0.9
	June	9	1.69	1.0	2.4	5	24	80	0.8
Children	April	22	1.85	1.4	2.7	5	26	115	1.2
	May	20	1.71	1.2	2.6	5	24	105	1.0
	June	23	1.78	1.3	2.6	5	25	95	1.1

[a] Iodine -131 and barium-140 values all 0 for this period.

ESTIMATED DAILY INTAKE OF RADIONUCLIDES IN CONNECTICUT STANDARD DIET, JANUARY-JUNE 1965

Connecticut State Department of Health

The Connecticut State Department of Health has been analyzing a standard diet on a monthly basis since March 1963. These analyses included strontium-89, strontium-90, and gamma-emitting radionuclides.

The standard diet was selected to represent the food intake of an 18-year-old boy for 1 day (table 1). The total weight of the complete blended diet, averaging 3 kilograms, included milk and dairy products. When raw fruit or vegetables were sampled, they were washed before blending.

Table 1. Foods included in standard diet

Bread, white—8 slices
Butter, ½ stick
Carrots, scraped—½ cup
Celery, washed and trimmed—3 stalks
Cookies—4
Cottage cheese—⅔ cup
Cupcakes—2
Egg—1
Green beans, washed—½ cup
Ham—85 grams
Hamburger—227 grams
Ice cream—½ pint
Lettuce, washed—4-5 leaves
Milk—3 cups
Oatmeal, uncooked—43 grams
Orange—1
Peanut butter—2½ tablespoons
Pears, canned—2 halves with juice
Potatoes, washed, not peeled—2
Sugar—5 tablespoons
Tomato juice—113 grams
Tuna fish, drained—43 grams

Cesium-137 radionuclide concentrations were determined by gamma-scintillation spectrometry (*1*). Strontium-89 and strontium-90 concentrations were determined by chemical separation techniques (*1*).

Table 2 presents the analytical results for the Connecticut standard diet from January through June 1965.

Table 2. Radionuclide concentrations in Connecticut standard diet,[a] January-June 1965

Month (1965)	Potassium (g/kg)	Strontium-90 (pCi/kg)	Cesium-137 (pCi/kg)
January	2.3	12.9	70
February	2.3	11.0	60
March	2.2	15.4	80
April	2.2	14.4	70
May	2.0	18.5	120
June	2.2	14.6	70

[a] All strontium-89 values <3 for this period.

Results representative of the total daily intake for the radionuclides observed are presented in table 3.

Table 3. Daily radionuclide intakes in Connecticut standard diet,[a] January-June 1965

Month (1965)	Potassium (g/day)	Strontium-90 (pCi/day)	Cesium-137 (pCi/day)
January	7.3	41.2	230
February	7.0	34.4	190
March	6.9	48.4	250
April	7.4	49.7	240
May	6.4	59.9	390
June	6.5	44.0	210

[a] All strontium-89 values <3 for this period.

In order to evaluate general trends, the strontium-90 and cesium-137 daily intakes are plotted as a function of time in figure 1.

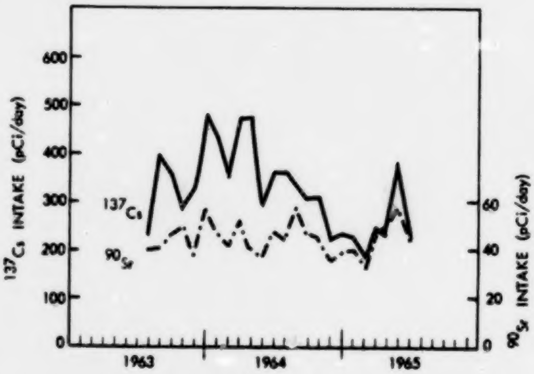

Figure 1. Radionuclide intake in Connecticut standard diet

REFERENCE

(*1*) CONNECTICUT STATE DEPARTMENT OF HEALTH. Estimated daily intake of radionuclides in Connecticut standard diet, March 1963—December 1964. Rad Health Data 6:381-382 (July 1965).

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
March 1963–December 1964	*July 1965*

Previous coverage in *Radiological Health Data and Reports*:

Activity	Period reported	Last presented
Institutional Total Diet	January–March 1965	*October 1965*
Tri-City Diet	February–April 1965	*December 1965*
Teenage Diet	February–November 1964	*July 1965*
California Diet	November–December 1964	*December 1965*
Connecticut Standard Diet	March 1963–December 1964	*July 1965*

Section II. Water

The Public Health Service (and as of January 1966, the Federal Water Pollution Control Administration) and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and/or treated (drinking) water. Most of these programs include determinations of gross alpha and gross beta radioactivity and/or specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the values secured with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively, without considering other sources of radioactivity. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the limits recommended by FRC for control action. In the known absence of strontium-90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity.[1] Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium-90, respectively.

GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, AUGUST 1965

Basic Data Branch
Federal Water Pollution Control Administration[2]

The monitoring of levels of radioactivity in surface waters of the United States was begun in 1957 as a part of the Public Health Service Water Pollution Surveillance System. Responsibility for this activity was transferred to the newly created Federal Water Pollution Control Administration on December 31, 1965. Table 1 presents the current preliminary results of the alpha and beta analyses. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 geographically presents the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytical procedures was published in the December 1965 issue of *RHD* (*5*).

Complete data and exact sampling locations are published in annual compilations (*6–11*) or are available on request.

Comments on data are being made when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. Changes toward or from these levels are discussed in terms of significant changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System

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[2] Data collected for this reporting period by the Division of Water Supply and Pollution Control.

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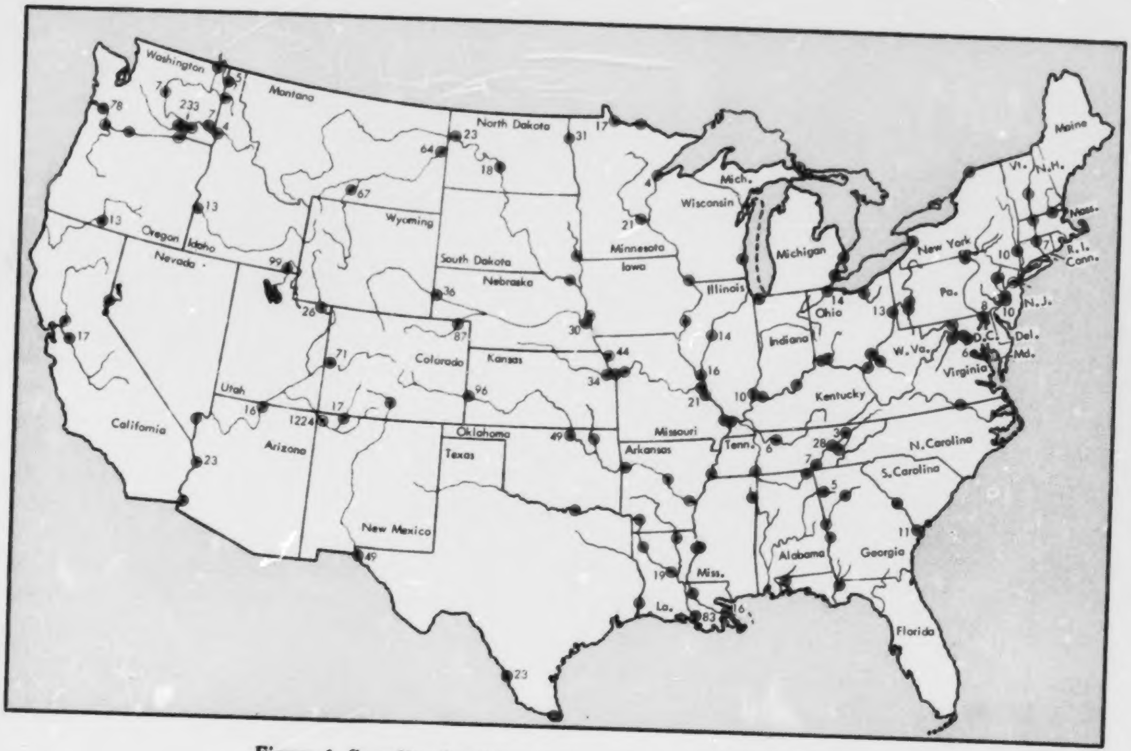
Washington
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North Dakota
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Oregon
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Nevada
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South Dakota
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Utah
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Kansas
71
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44
California
16
1224
17
Arizona
Oklahoma
Texas
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23
New Mexico
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Minnesota
Iowa
Wisconsin
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Mich.
Michigan
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Indiana
Ohio
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Missouri
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Kentucky
Tenn.
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N.Carolina
S.Carolina
Alabama
Georgia
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Miss.
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La.
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Florida
New York
Pa.
W.Va.
Virginia
D.C.
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Md.
Del.
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Conn.
R.I.
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Mass.
Vt.
N.H.
Maine

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, August 1965

will be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

The following stations showed alpha values on suspended and/or dissolved solids of 15 pCi/liter or more for both July and August: South Platte River, Julesburg, Colorado and Yellowstone River, Sidney, Montana. These stations showed reasonable values for alpha radioactivity per gram of suspended and/or dissolved solids. The following stations showed a decline to an alpha radioactivity of less than 15 pCi/liter from the month of July: Kansas River, DeSoto, Kansas; Missouri River, St. Joseph, Missouri; and Platte River, Plattsmouth, Nebraska. The following stations showed increases of alpha radioactivity from less than 15 pCi/liter in July to more than this value for August 1965; Arkansas River, Coolidge, Kansas; North Platte River, Henry, Nebraska; Atchafalaya River, Morgan City, Louisiana; Missouri River, Bismarck, North Dakota; San Juan River, Shiprock, New Mexico; Colorado River, Loma, Colorado; and an increase in dissolved solids beta activity of sample from the Columbia River at Pasco, Washington. At Morgan City, the high level of suspended solids is responsible for the high activities observed. Coolidge, Kansas, shows high suspended and dissolved solids while Henry, Nebraska, shows high dissolved solids with a characteristic alpha activity per gram. Shiprock is interesting in that the first sample of three collected during the month had suspended solid levels in excess of 50,000 mg/liter. This, in turn, produced high alpha and high beta activities for both suspended and dissolved solids, even though the latter two samples showed usual low activities and normal solids concentration. Pasco showed increased beta activity on dissolved solids. The period of high river flow is now past and concentrations of dissolved solids are again at higher levels.

Table 1. Radioactivity in raw surface waters, August 1965

(Average concentrations in pCi/liter)

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	11	6	17	4	1	5
Arkansas River:						
Coolidge, Kans	70	26	96	27	7	34
Ponca City, Okla	24	25	49	5	10	15
Atchafalaya River:						
Morgan City, La	69	14	83	29	2	31
Bear River:						
Preston, Idaho	11	88	99	3	2	5
Big Horn River:						
Hardin, Mont	45	22	67	9	7	16
Chena River:						
Fairbanks, Alaska	0	3	3	0	<1	<1
Clearwater River:						
Lewiston, Idaho	1	3	4	<1	0	<1
Clinch River:						
Clinton, Tenn	0	3	3	0	0	0
Kingston, Tenn	4	24	28	<1	0	<1
Colorado River:						
Loma, Colo	55	16	71	19	8	27
Page, Ariz	1	15	16	0	3	3
Parker Dam, Calif-Ariz	1	22	23	0	12	12
Columbia River:						
Wenatchee, Wash	1	6	7	0	1	1
Pasco, Wash	47	186	233	0	1	1
Clatskanie, Ore	13	65	78	0	<1	<1
Connecticut River:						
Enfield Dam, Conn	1	6	7	0	0	0
Coosa River:						
Rome, Ga	1	4	5	<1	<1	<1
Cumberland River:						
Cheatham Lock, Tenn	1	5	6	0	0	0
Delaware River:						
Philadelphia, Pa	2	8	10	0	0	0
Great Lakes:						
Duluth, Minn	1	3	4	0	0	0
Green River:						
Dutch John, Utah	1	25	26	0	5	5
Hudson River:						
Poughkeepsie, N.Y	1	9	10	0	0	0
Illinois River:						
Peoria, Ill	1	13	14	0	2	2
Grafton, Ill	2	14	16	0	2	2
Kansas River:						
De Soto, Kans	12	22	34	4	2	6
Klamath River:						
Keno, Ore	<1	13	13	0	<1	<1
Maumee River:						
Toledo, Ohio	2	12	14	0	1	1
Mississippi River:						
St. Paul, Minn	1	20	21	0	1	1
E. St. Louis, Ill	3	18	21	1	2	3
New Orleans, La	4	12	16	1	1	2
Missouri River:						
Williston, N. Dak	4	19	23	1	7	8
Bismarck, N. Dak	1	17	18	<1	7	7
St. Joseph, Mo	24	20	44	10	5	15
North Platte River:						
Henry, Nebr	9	27	36	1	25	26
Ohio River:						
Toronto, Ohio	1	12	13	0	0	0
Cairo, Ill	1	8	9		0	0
Pend Oreille River:						
Albeni Falls Dam, Idaho	<1	5			1	1
Platte River:						
Plattsmouth, Nebr	8	22	30	2	4	6
Potomac River:						
Washington, D.C	0	6	6	0	0	0
Rainy River:						
Baudette, Minn	1	16	17	0	0	0
Red River, North:						
Grand Forks, N. Dak	4	27	31	1	2	3
Red River, South:						
Alexandria, La	2	17	19	0	2	
Rio Grande:						
El Paso, Tex	32	17	49	13	3	16
Laredo, Tex	8	15	23	1	3	4
San Joaquin River:						
Vernalis, Calif	5	12	17	1	10	11
San Juan River:						
Shiprock, N. Mex	1,201	23	1,224	288	3	291
Savannah River:						
Port Wentworth, Ga	3	8	11	0	0	0
Snake River:						
Payette, Idaho	1	12	13	0	5	5
Wawawai, Wash	1	6	7	0	1	1
South Platte River:						
Julesburg, Colo	43	44	87	17	28	45
Susquehanna River:						
Conowingo, Md	0	8	8	0	0	0
Tennessee River:						
Chattanooga, Tenn	0	7	7	0	0	0
Wabash River:						
New Harmony, Ind	1	9	10	0	<1	<1
Yellowstone River:						
Sidney, Mont	53	11	64	17	4	21
Maximum	1,201	186	1,224	288	28	291
Minimum	0	3	3	0	0	0

NS, no sample.

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(1) PUBLIC HEALTH SERVICE. Drinking Water Standards, revised 1962. Public Health Service Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963). Price 30 cents.

(2) FEDERAL RADIATION COUNCIL. Radiation protection guidance for Federal agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(3) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(4) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

(5) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. Gross radioactivity in surface waters of the United States, June 1965. Rad Health Data 6:707–710 (December 1965).

(6) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. National water quality network annual compilation of data. PHS Publication No. 663, 1958 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402. Price $1.50.

(7) *Ibid.*, 1959 Edition. Price $1.75.

(8) *Ibid.*, 1960 Edition.

(9) *Ibid.*, 1961 Edition.

(10) *Ibid.*, 1962 Edition.

(11) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. Water pollution surveillance system, annual compilation of data. PHS Publication No. 663 (revised) 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

RADIOACTIVITY IN MINNESOTA MUNICIPAL WATER SUPPLIES[3] JANUARY–JUNE 1965

Division of Environmental Sanitation
Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity concentration was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at Crookston International Falls, and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

The samples are forwarded to the Division's laboratory, where they are analyzed for gross beta activity. A 250–ml sample of water is transferred to a 2-inch planchet and evaporated at 75°C. The solid residue (suspended-plus-dissolved solids) is fixed by adding lucite in acetone. The sample is then counted for beta activity in an internal-proportional counter. Counter standardization is accomplished by adding known amounts of thallium–204 standard to solutions containing the normal range of solids.

Table 1 shows a summary of the monthly average gross beta activity in Minnesota

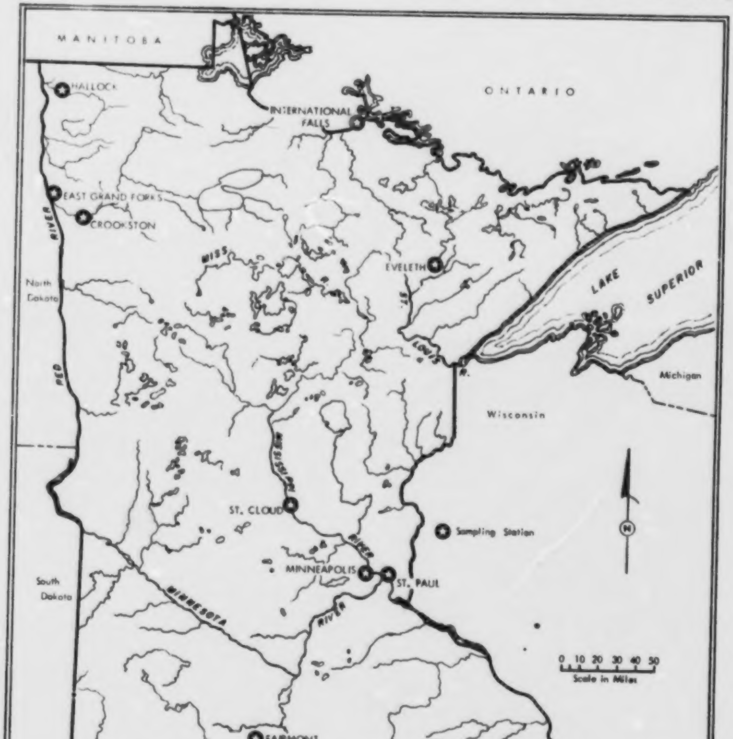
MANITOBA
HALLOCK
INTERNATIONAL FALLS
ONTARIO
EAST GRAND FORKS
CROOKSTON
RIVER
MISS
EVELETH
North Dakota
RED
LAKE SUPERIOR
ST. LOUIS R.
Michigan
Wisconsin
ST. CLOUD
MISSISSIPPI
RIVER
Sampling Station
N
MINNEAPOLIS
ST. PAUL
South Dakota
MINNESOTA
RIVER
0 10 20 30 40 50
Scale in Miles
FAIRMONT
Iowa

Figure 1. Minnesota surface water sampling locations

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[3] Data and information from "Survey of Environmental Radioactivity, January–June 1965," Publication No. COO–651–17. State of Minnesota Department of Public Health, University Campus, Minneapolis, Minnesota 55440.

Table 1. Total beta concentrations in Minnesota raw and treated water supplies, January–June 1965

(Monthly average concentrations in pCi/liter)

Town and water source	Type of water	Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	48	44	31	NS	20	51
	Treated	48	26	29	NS	30	36
East Grand Forks, Red Lake River	Raw	34	36	16	36	28	41
	Treated	13	16	12	23	13	23
Eveleth, St. Mary's Lake	Raw	30	19	17	23	20	24
	Treated	17	17	16	25	24	7
Fairmount, Budd Lake	Raw	24	13	20	13	20	26
	Treated	11	7	15	15	10	7
Hallock, Two Rivers South Fork	Raw	38	41	43	35	45	54
	Treated	10	13	7	11	14	12
International Falls, Rainy River	Raw	19	32	12	28	NS	13
	Treated	22	23	12	16	NS	7
Minneapolis tap water	Raw	NS	NS	NS	NS	NS	NS
	Treated	10	10	7	9	7	9
St. Cloud, Mississippi River	Raw	NS	15	7	22	NS	22
	Treated	NS	7	13	15	NS	7
St. Paul, Vadnais Chain of Lakes	Raw	18	13	12	23	18	32
	Treated	7	10	10	10	15	13

NS, no samples collected

municipal water supplies from January-June 1965. The minimum reported level corresponding to an error of one standard deviation is 15 pCi/liter at present. In averaging, the value 7 pCi/liter is used for samples having less than the minimum detectable value.

The data obtained on gross beta activity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this variation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 7 to 54 pCi/liter, which is well below the Public Health Service Drinking Water Standards of 1,000 pCi/liter (*1*). Treated water in most cases contained less beta activity than the corresponding raw water.

REFERENCE

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962. Public Health Service Publication No. 956, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963). Price 30 cents.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
October 1957–August 1959	*April 1960*
August 1959–April 1962	*August 1962*
April 1962–November 1962	*April 1963*
December 1962–June 1963	*November 1963*
July–December 1963	*June 1964*
January–June 1964	*January 1965*
July–December 1964	*August 1965*

Other State coverage:

Program	Period covered	Last presented
California surface water sampling program	July–December 1964	*September 1965*
Florida water sampling program	1964	*November 1965*
Kentucky water sampling program	May 1963–June 1964	*March 1965*
New York surface water sampling program	June–December 1964	*September 1965*
North Carolina water sampling program	January–December 1964	*November 1965*
Washington surface water sampling program	July 1963–June 1964	*February 1965*

Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used for determining when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercalibration of the above networks was performed by Lockhart (*1*) in 1962.

1. Radiation Surveillance Network
October 1965

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network Laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples. When high air levels are reported, appropriate officials are promptly notified. Compilation of daily field estimates

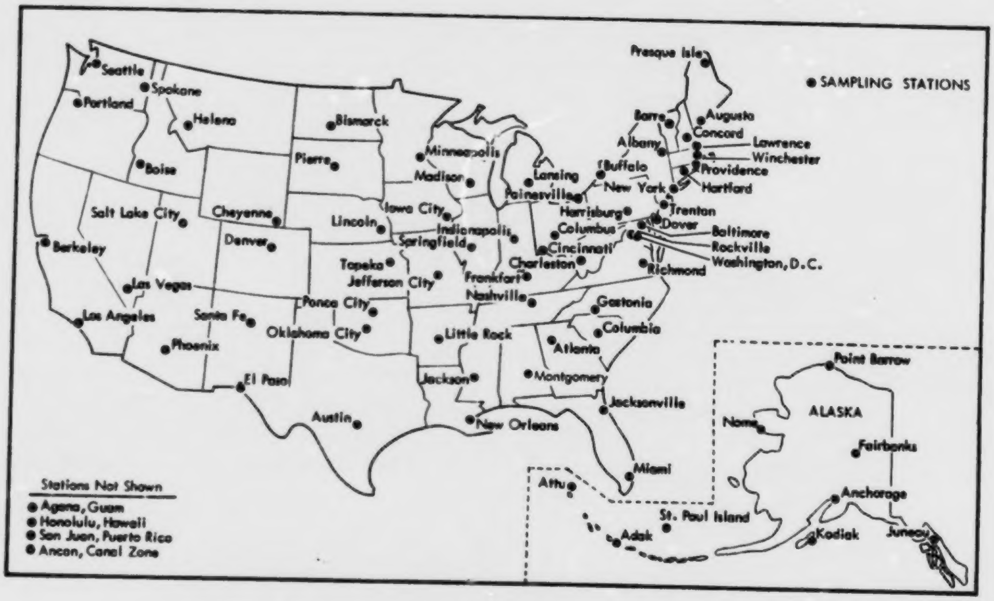
● SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Boise
Bismarck
Pierre
Minneapolis
Madison
Salt Lake City
Cheyenne
Lincoln
Iowa City
Berkeley
Denver
Indianapolis
Springfield
Topeka
Jefferson City
Frankfort
Las Vegas
Ponca City
Nashville
Los Angeles
Santa Fe
Oklahoma City
Little Rock
Phoenix
El Paso
Jackson
Austin
New Orleans
Presque Isle
Barre
Augusta
Concord
Albany
Lawrence
Winchester
Providence
Hartford
Buffalo
Lansing
New York
Painesville
Harrisburg
Trenton
Columbus
Dover
Baltimore
Cincinnati
Rockville
Washington, D.C.
Charleston
Richmond
Gastonia
Columbia
Atlanta
Montgomery
Jacksonville
Miami
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta activity in surface air and precipitation, October 1965

Station location		Air surveillance						Precipitation	
		Number of samples		Gross beta activity, pCi/m³			Last profile in *RHD & R*	Total depth (mm)	Total deposition (nCi/m²)[a]
		Air	Ppt	Maximum	Minimum	Average			
Ala:	Montgomery	31	2	0.31	<0.10	<0.11	Feb 66	124	<25
Alaska:	Adak	30		<0.10	<0.10	<0.10	Sep 65	[c] —	
	Anchorage	20	4	<0.10	<0.10	<0.10	May 65	24	<5
	Attu Island	11		0.16	<0.10	<0.10	Oct 65	—	
	Fairbanks	(b)					Jun 65	—	
	Juneau	7	5	<0.10	<0.10	<0.10	Jul 65	59	<12
	Kodiak	2		<0.10	<0.10	<0.10	Aug 65	—	
	Nome	15		<0.10	<0.10	<0.10	Dec 65	—	
	Point Barrow	(b)					Nov 65	—	
	St. Paul Island	28		<0.10	<0.10	<0.10	Jan 66	—	
Ariz:	Phoenix	25		0.19	<0.10	<0.11	Jul 65	—	
Ark:	Little Rock	25	1	0.16	<0.10	<0.10	Jun 65	4	<1
Calif:	Berkeley	20	1	<0.10	<0.10	<0.10	Aug 65	6	<1
	Los Angeles	20		0.12	<0.10	<0.10	Dec 65	—	
C. Z:	Ancon	15		<0.10	<0.10	<0.10	Aug 65	—	
Colo:	Denver	30	2	0.16	<0.10	<0.10	Aug 65	15	<3
Conn:	Hartford	31	9	<0.10	<0.10	<0.10	Jul 65	88	<18
Del:	Dover	20		0.11	<0.10	<0.10	Feb 66	—	
D. C:	Washington	29	7	0.14	<0.10	<0.10	Nov 65	49	<10
Fla:	Jacksonville	31	8	0.15	<0.10	<0.10	Jun 65	46	<9
	Miami	27	10	0.14	<0.10	<0.10	Jul 65	158	<32
Ga:	Atlanta	(b)	1				Jan 66	11	<2
Guam:	Agana	30		0.14	<0.10	<0.10	Feb 66	—	
Hawaii:	Honolulu	30	4	<0.10	<0.10	<0.10	Oct 65	93	<19
Idaho:	Boise	27	1	0.12	<0.10	<0.10	Oct 65	9	<2
Ill:	Springfield	30		0.15	<0.10	<0.10	Nov 65	—	
Ind:	Indianapolis	28	9	0.11	<0.10	<0.10	Jan 66	35	<7
Iowa:	Iowa City	31	4	<0.10	<0.10	<0.10	Aug 65	40	<8
Kans:	Topeka	29	3	0.11	<0.10	<0.10	May 65	26	<5
Ky:	Frankfort	29	5	0.14	<0.10	<0.10	Nov 65	36	<14
La:	New Orleans	31	3	0.14	<0.10	<0.10	Nov 65	31	<6
Maine:	Augusta	31	11	<0.10	<0.10	<0.10	Dec 65	113	<23
	Presque Isle	11	7	<0.10	<0.10	<0.10	Aug 65	72	<14
Md:	Baltimore	20	6	0.13	<0.10	<0.10	Jul 65	32	<7
	Rockville Lab	13		0.11	<0.10	<0.10	Oct 65	—	
Mass:	Lawrence	31	7	<0.10	<0.10	<0.10	Feb 66	49	<10
	Winchester	30	5	<0.10	<0.10	<0.10	Sep 65	42	<8
Mich:	Lansing	31	8	0.12	<0.10	<0.10	Oct 65	46	<9
Minn:	Minneapolis	20	3	<0.10	<0.10	<0.10	Feb 66	34	<7
Miss:	Jackson	26	1	0.16	<0.10	<0.10	Dec 65	34	<7
Mo:	Jefferson City	31	5	<0.10	<0.10	<0.10	Jan 66	76	<15
Mont:	Helena	30	2	0.13	<0.10	<0.10	Sep 65	3	<1
Nebr:	Lincoln	18		0.16	<0.10	<0.11	Jan 66	—	
Nev:	Las Vegas	29		0.18	<0.10	<0.11	Jun 65	—	
N. H:	Concord	18		0.12	<0.10	<0.10	Nov 65	—	
N. J:	Trenton	30	4	0.12	<0.10	<0.10	Dec 65	9	<2
N. Mex:	Santa Fe	27	3	0.11	<0.10	<0.10	Sep 65	42	<8
N. Y:	Albany	18	7	0.11	<0.10	<0.10	Jan 66	46	<9
	Buffalo	26		0.17	<0.10	<0.11	Aug 65	—	
	New York	31		0.11	<0.10	<0.10	Sep 65	—	
N. C:	Gastonia	31	6	0.13	<0.10	<0.10	Aug 65	57	<11
N. Dak:	Bismarck	28	1	0.12	<0.10	<0.10	Nov 65	15	<3
Ohio:	Cincinnati	21		<0.10	<0.10	<0.10	Feb 66	—	
	Columbus	29	11	0.16	<0.10	<0.11	Dec 65	117	<23
	Painesville	30	10	0.15	<0.10	<0.10	Jul 65	107	<22
Okla:	Oklahoma City	30	1	0.14	<0.10	<0.11	Oct 65	17	<3
	Ponca City	27	1	<0.10	<0.10	<0.10	Jul 65	5	<1
Ore:	Portland	31	8	0.26	<0.10	<0.14	Jan 66	44	<9
Pa:	Harrisburg	30	5	<0.10	<0.10	<0.10	Jan 66	72	<14
P. R:	San Juan	22	1	<0.10	<0.10	<0.10	Dec 65	28	<6
R. I:	Providence	28	6	<0.10	<0.10	<0.10	Oct 65	67	<13
S. C:	Columbia	29	5	0.11	<0.10	<0.10	Sep 65	12	<2
S. Dak:	Pierre	31	1	0.12	<0.10	<0.10	Jul 65	12	<2
Tenn:	Nashville	31	5	0.11	<0.10	<0.10	Oct 65	36	<7
Tex:	Austin	30	4	0.14	<0.10	<0.10	Feb 66	92	<19
	El Paso	29	1	0.18	<0.10	<0.11	Nov 65	4	<1
Utah:	Salt Lake City	31	1	0.20	<0.10	<0.11	Dec 65	13	<3
Vt:	Barre	30	13	<0.10	<0.10	<0.10	Jun 65	58	<12
Va:	Richmond	31	5	<0.10	<0.10	<0.10	Jun 65	36	<7
Wash:	Seattle	31	8	<0.10	<0.10	<0.10	May 65	34	<7
	Spokane	31		0.15	<0.10	<0.11	Feb 66	—	
W. Va:	Charleston	30	6	0.15	<0.10	<0.10	Sep 65	55	<11
Wis:	Madison	30	7	<0.10	<0.10	<0.10	Jun 65	58	<12
Wyo:	Cheyenne	31	2	0.13	<0.10	<0.10	Jun 65	22	<4
Network summary		1,855	256	0.31	<0.10	<0.10		45	<9

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[a] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.

[b] No report received.

[c] Dash indicates no precipitation sample collected.

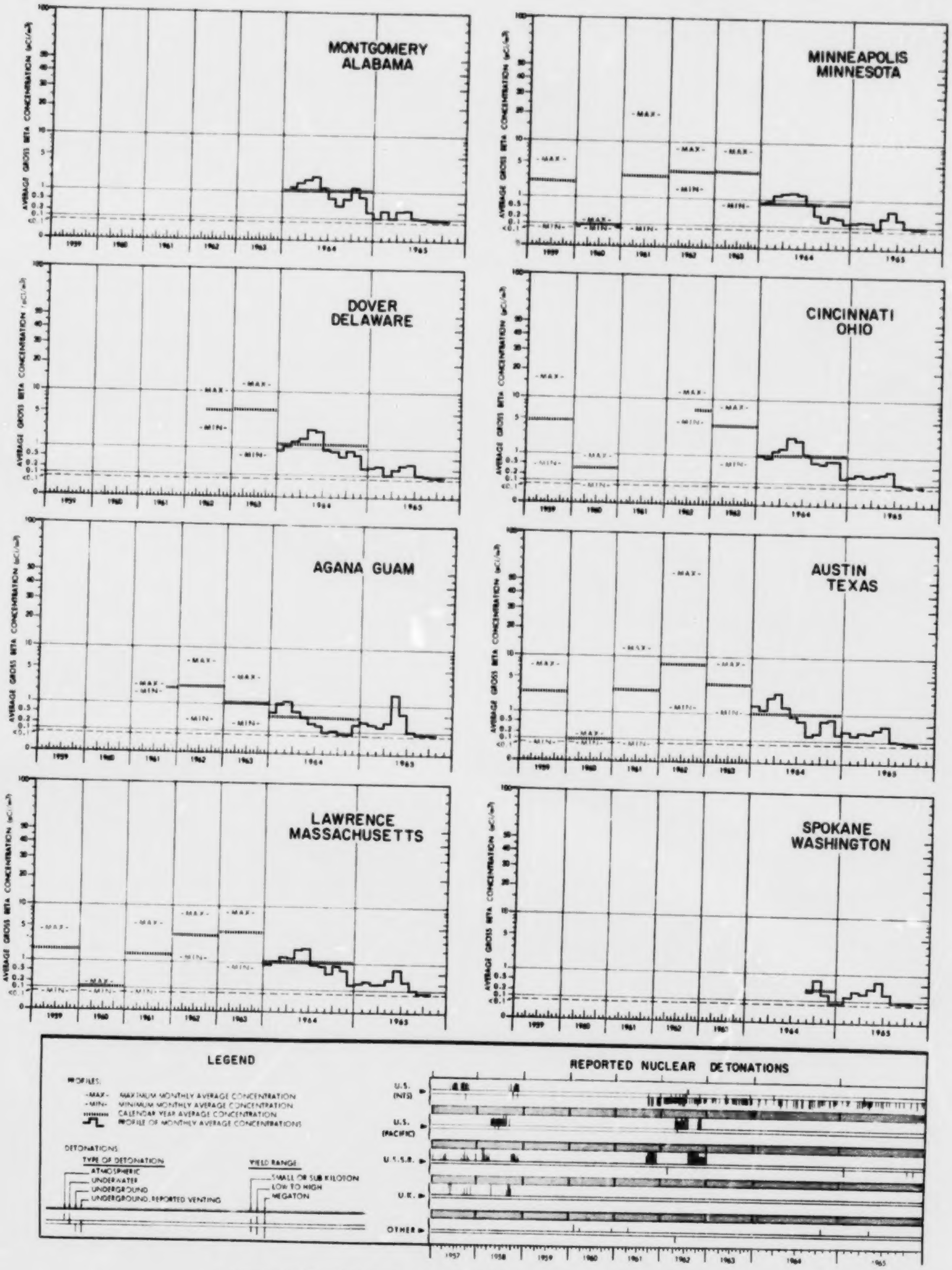

Figure 2. Monthly and yearly profiles of beta activity in air—Radiation Surveillance Network, 1959–October 1965

and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analysis procedures was presented in the December 1965 issue of *Radiological Health Data*.

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during October 1965. Time profiles of gross beta in air dating back to 1958 for eight RSN stations are shown in figure 2. Gamma spectroscopy analysis was performed on 298 air samples. Traces of longer-lived products such as manganese-54, zinc-65, ruthenium-rhodium-106, antimony-125, cesium-137, and cerium-promethium-144 were identified in most of these.

2. Canadian Air and Precipitation Monitoring Program[1] October 1965

Radiation Protection Division
Department of National
Health and Welfare, Ottawa, Canada

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data*.

Surface air and precipitation data for October 1965 are presented in table 2. Specific radionuclide data are presented in table 3.

Table 2. Canadian gross beta activity in surface air and precipitation, October 1965

Station	Air surveillance				Precipitation measurements	
	Number of samples	Activity (pCi/m³)			Average concentration (pCi/liter)	Total deposition (nCi/m²)
		Maximum	Minimum	Average		
Calgary	31	0.2	0.0	0.1	110	1.3
Coral Harbour	31	0.1	0.0	0.0	56	0.7
Edmonton	31	0.1	0.0	0.1	131	0.7
Ft. Churchill	28	0.1	0.0	0.0	51	2.4
Ft. William	30	0.1	0.0	0.1	65	1.6
Fredericton	31	0.1	0.0	0.0	41	2.6
Goose Bay	30	0.1	0.0	0.0	27	1.9
Halifax	31	0.1	0.0	0.1	33	3.2
Inuvik	30	0.1	0.0	0.0	24	0.6
Montreal	29	0.1	0.0	0.1	28	3.6
Moosonee	31	0.1	0.0	0.0	32	3.4
Ottawa	31	0.1	0.0	0.1	23	3.0
Quebec	30	0.1	0.0	0.0	14	2.5
Regina	30	0.1	0.0	0.1	(a)	0.4
Resolute	13	0.1	0.0	0.0	125	1.9
St. John's, Nfld	28	0.1	0.0	0.0	35	3.6
Saskatoon	30	0.1	0.0	0.1	(a)	0.6
Sault Ste. Marie	30	0.1	0.0	0.1	29	2.7
Toronto	31	0.1	0.0	0.1	30	2.9
Vancouver	31	0.1	0.0	0.1	27	4.1
Whitehorse	31	0.1	0.0	0.0	24	0.8
Windsor	31	0.1	0.0	0.1	15	1.5
Winnipeg	31	0.1	0.0	0.1	91	1.3
Yellowknife	29	0.1	0.0	0.0	41	1.0
Network summary	709	0.2	0.0	0.1	48	2.0

[a] Trace

Table 3. Radionuclide deposition, nCi/m², in Canadian fallout, October 1965

Station	^{90}Sr	^{137}Cs
Calgary	0.10	0.14
Coral Harbour	0.05	0.10
Edmonton	0.05	0.06
Ft. Churchill	0.31	0.42
Ft. William	0.13	0.20
Fredericton	0.28	0.32
Goose Bay	0.13	0.18
Halifax	0.24	0.41
Inuvik	0.00	0.07
Montreal	0.35	0.46
Moosonee	0.22	0.30
Ottawa	0.29	0.35
Quebec	0.22	0.24
Regina	0.00	0.12
Resolute	0.09	0.20
St. John's, Nfld	0.25	0.37
Saskatoon	0.03	0.06
Sault Ste. Marie	0.30	0.23
Toronto	0.23	0.43
Vancouver	0.32	0.46
Whitehorse	0.06	0.14
Windsor	0.12	0.16
Winnipeg	0.12	0.11
Yellowknife	0.06	0.13

[a] Samples from all stations are routinely analyzed for strontium-89, strontium-90, and cesium-137; samples from five selected stations are regularly analyzed for zirconium-95 and barium-140. Strontium-89, zirconium-95 and barium-140 are not reported due to insignificant levels.

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[1] Prepared from information and data in the October 1965 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

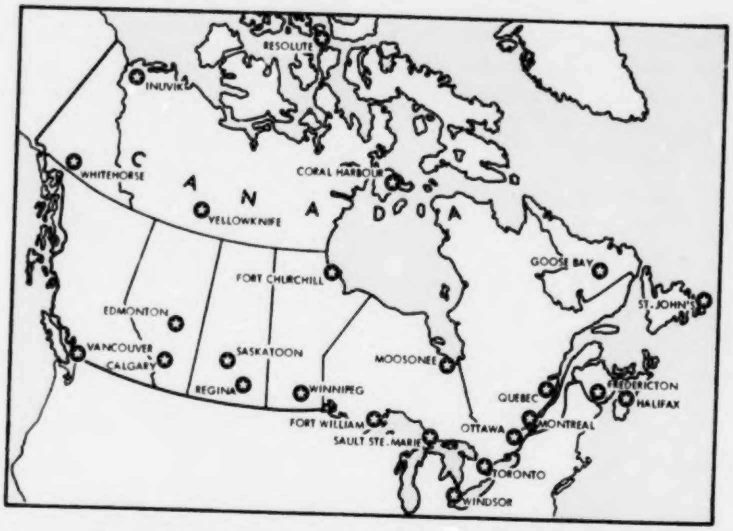
RESOLUTE
INUVIK
C
A
N
A
D
A
WHITEHORSE
YELLOWKNIFE
CORAL HARBOUR
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
SAULT STE. MARIE
OTTAWA
MONTREAL
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

3. Mexican Monitoring Program
October 1965

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico is operated by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961, an earlier network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*8–12*).

The new Radiation Surveillance Network, operated by CNEN's Division of Radiological Protection, consists of 17 stations (see figure 4), 12 of which are located at airports and operated by airline personnel. The remaining five stations are operated by staff members of other agencies.

Details of sampling procedures were outlined in the December 1965 issue of *Radiological Health Data.*

Table 4 presents the maximum, minimum, and average gross beta activity concentrations in surface air during October.

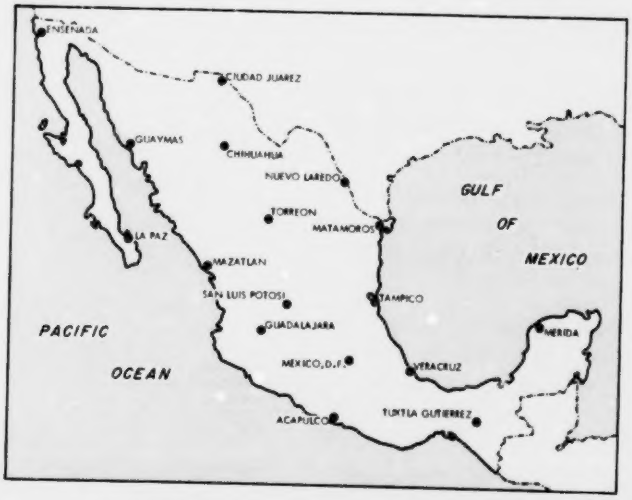
ENSENADA
CIUDAD JUAREZ
GUAYMAS
CHIHUAHUA
NUEVO LAREDO
TORREON
MATAMOROS
GULF
OF
MEXICO
LA PAZ
MAZATLAN
SAN LUIS POTOSI
TAMPICO
GUADALAJARA
MERIDA
PACIFIC
OCEAN
MEXICO, D.F.
VERACRUZ
ACAPULCO
TUXTLA GUTIERREZ

Figure 4. Mexican air sampling station locations

Table 4. Mexican gross beta activity of airborne particulates, October 1965

Station	Number of samples	Gross beta activity (pCi/m^3)		
		Maximum	Minimum	Average
Acapulco	15	0.1	<0.1	<0.1
Ciudad Juárez	11	0.2	<0.1	0.1
Chihuahua	17	0.2	<0.1	0.1
Enseñada	13	0.2	<0.1	0.1
Guadalajara	5	<0.1	<0.1	<0.1
Guaymas	8	0.1	<0.1	0.1
La Paz	7	0.1	<0.1	0.1
Matamoros	19	<0.1	<0.1	<0.1
Mazatlán	8	0.1	<0.1	0.1
Mérida	15	0.1	<0.1	<0.1
México, D.F.	14	0.1	<0.1	<0.1
Nuevo Laredo	1			
San Luis Potosí	10	0.1	<0.1	<0.1
Tampico	20	0.1	<0.1	<0.1
Torréon	25	0.2	<0.1	0.1
Tuxtla Gutiérrez[a]				
Veracruz	18	0.1	<0.1	<0.1

[a] Station temporarily shut down.

4. Pan American Air Sampling Program October 1965

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization (PAHO) and the Public Health Service (PHS) to assist PAHO-member countries in developing radiological heath programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling station locations are shown in figure 5.

The October 1965 air monitoring results from the participating countries were all below the reportable limit of 0.10 pCi/m^3.

REFERENCES

(*1*) LOCKHART, L. B., JR., and R. L. PATTERSON, JR. Intercalibration of the major North American networks employed in monitoring airborne fission products. NRL Report 6025, Naval Research Laboratory, Washington, D.C. 20390 (December 1963); summarized in Rad Health Data 5:12–15 (January 1964).

(*2*) RADIATION SURVEILLANCE NETWORK. Monthly tabulation of findings. Division of Radiological Health, Public Health Service. Washington, D.C. 20201 (Distribution by official request).

(*3*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1959 on the Radioactive Fallout Study Program. CNHW-RP-3, Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*4*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program. CNHW-RP-4, Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*5*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program. CNHW-RP-5, Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*6*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program. RPD-11, Department of National Health and Welfare, Ottawa, Canada (July 1962).

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(*11*) ALBA, F., T. A. BRODY, and A. PALACIOS. Cuarto informe sobre estudios de la precipitacion radiactiva. Revista Mexicana de Física 8:61–85 (1959).

(*12*) BRODY, T. A., S. BULBULIAN, J. CALVILLO, and A. M. MARTINEZ. Quinto informe sobre estudios de precipitacion radiactiva. Revista Mexicana de Física 10:1–30 (1961).

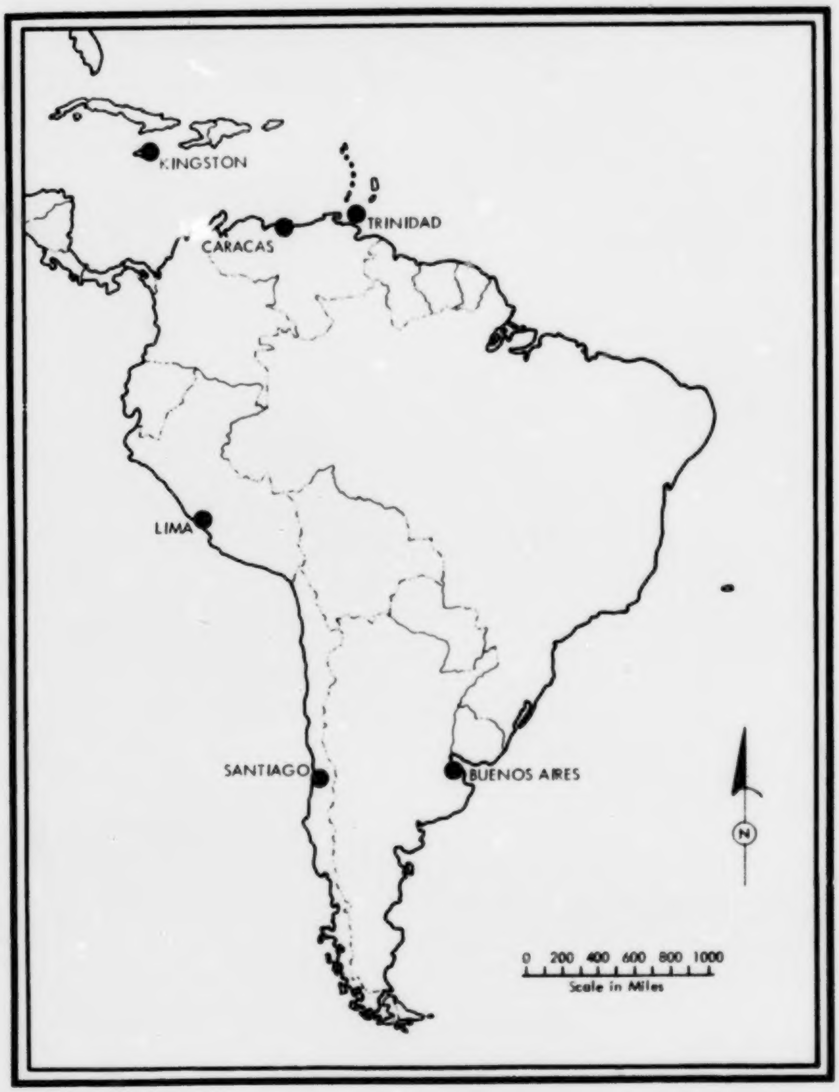
KINGSTON
TRINIDAD
CARACAS
LIMA
SANTIAGO
BUENOS AIRES
N
0 200 400 600 800 1000
Scale in Miles

Figure 5. Pan American Air Network sampling stations

Other Programs Covered in *Radiological Health Data and Reports:*

Program	Period	Issue
HASL Fallout Network	April-December 1964	*September 1965*

Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such typical data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual." [1]

Summaries of the environmental radioactivity data follow for the Hanford Atomic Products Operation, the Pinellas Peninsula Plant, the Savannah River Plant, and the Shippingport Atomic Power Station.

1. Hanford Atomic Products Operation[2]
Calendar Year 1964

General Electric Company
Richland, Washington

An evaluation of the results obtained from the Hanford environmental surveillance program for 1964 indicates that most of the environmental radiation exposure for the majority of persons living in the neighborhood of the Hanford project was due to natural sources and worldwide fallout rather than to Hanford operations.

Of the low-level wastes that are released to the environment from the Hanford plants, neutron-induced radionuclides present in reactor cooling water discharged to the Columbia River continued to be the source of greatest potential exposure above background to people in the environs. The primary mechanisms of exposure from this source are drinking water derived from the river, consumption of fish and waterfowl which inhabit the river, and foodstuffs grown on land irrigated with water pumped from the Columbia downstream from Hanford.

Residents of Richland were supplied throughout the year with drinking water from a new treatment plant that draws water from the Columbia River. The radiation exposure from drinking this water was estimated to be about 10 percent of the appropriate limit. The gastrointestinal tract is the limiting organ for the mixture of radionuclides present in drinking water pumped from the Columbia River. In Pasco and Kennewick, which are further downriver, the estimated exposures from drinking water were respectively about 5 percent to 1 percent of the limit for the GI tract. The only persons who received radiation exposures attributable to Hanford that were greater than those that resulted from the drinking water were the people who ate local fish or waterfowl or who regularly consumed produce from nearby farms irrigated with water taken from

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[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

[2] Summarized from Pacific Northwest Laboratory, "Evaluation of Radiological Conditions in the Vicinity of Hanford for 1964," BNWL-90 (July 1965).

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the Columbia River below the reactors.

The highly unlikely but plausible combination of circumstances that would result in the greatest exposure to an individual from the radionuclides released by the Hanford plants is postulated as (1) the consumption of some 200 meals per year (4 meals per week) of fish caught downstream from the reactors, (2) the consumption of meat, milk, fruit, and vegetables grown on irrigated farms in the Riverview District, and (3) the consumption of drinking water from the Pasco system.

An individual with such habits could conceivably ingest enough radioactive materials of Hanford origin (mostly phosphorus-32) to supply about 25 percent of the annual permissible amount. For this "maximum" individual the bone is the most restrictive organ. This same individual could also ingest enough strontium-90 of worldwide fallout origin to equal about 2 percent of the permissible amount—substantially less than the amount estimated for 1963.

Iodine-131 in the Hanford environs remained at very low concentrations in 1964. The Chinese nuclear test on October 16 caused a brief increase in iodine-131, but concentrations soon returned to the low levels experienced during most of 1964. The postulated "maximum" exposure from iodine-131 to the thyroid of a small child amounted to only about 5 percent of the Radiation Protection Guide recommended for individuals by the Federal Radiation Council.

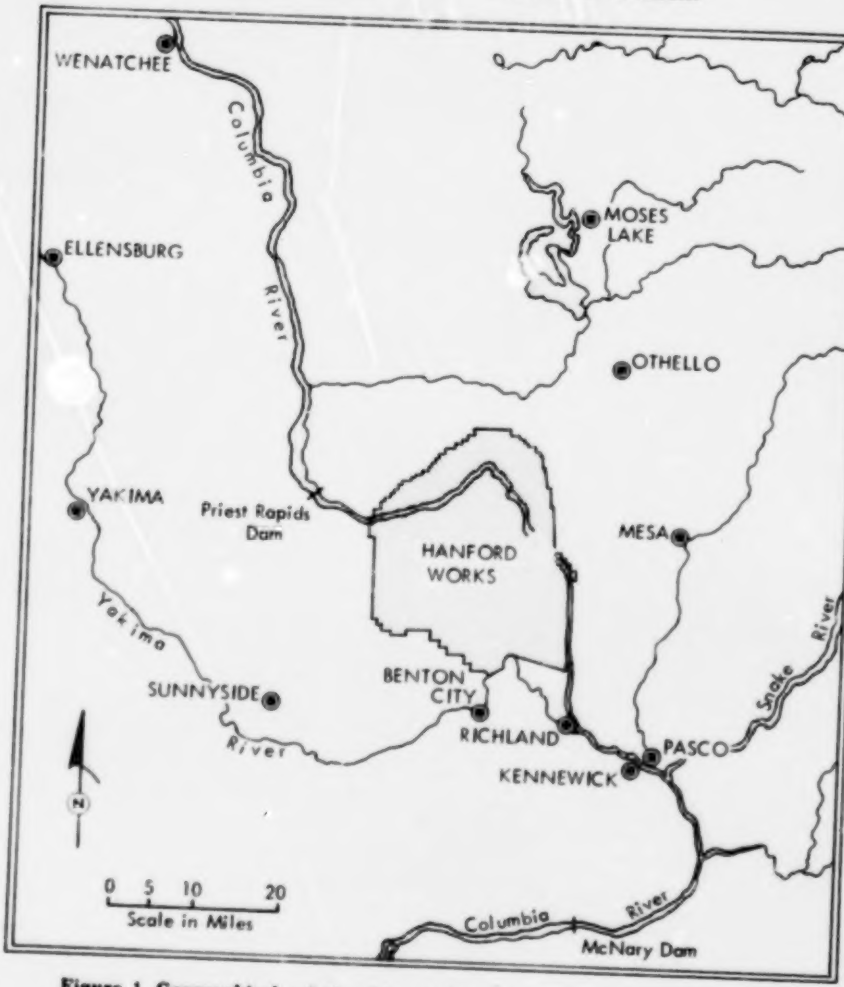
WENATCHEE
Columbia
River
MOSES LAKE
ELLENSBURG
OTHELLO
YAKIMA
Priest Rapids Dam
HANFORD WORKS
MESA
Yakima
River
SUNNYSIDE
BENTON CITY
RICHLAND
PASCO
KENNEWICK
Snake River
N
0 5 10 20
Scale in Miles
Columbia River
McNary Dam

Figure 1. Geographical relationship of Hanford works to Pacific Northwest

The Hanford project[3] (figure 1) is located in a semiarid region of Southeastern Washington State where the average annual rainfall is about 7 inches. This section of the State has a sparse covering of natural vegetation, primarily suited for grazing, although large areas near the project have gradually been put under irrigation during the past few years. The plant site covers an area of about 500 square miles. The Columbia River flows through the northern edge of the project and forms part of the eastern boundary. The meteorology of the region is typical of desert areas with frequent strong inversions occurring at night and breaking during the day to provide unstable and turbulent conditions. Near the plant production sites the prevailing winds are from the northwest with strong drainage and cross winds causing distorted flow patterns.

The populated areas of primary interest are the Tri-Cities (Richland, Pasco, and Kennewick) situated on the Columbia River directly downstream from the plant. Smaller communities in the vicinity are Benton City, West Richland, Mesa, and Othello, and these, together with the surrounding agricultural area, bring the total population near the plant to about 80,000 people.

During the course of operation, various radioactive wastes are generated by the several plant facilities. High level wastes are concentrated and retained in storage within the project boundaries. Controlled releases of low-level wastes, for which concentration and storage are not feasible or necessary, are made to the ground. The Hanford practices governing radioactive waste disposal are described in the Hearings on Industrial Radioactive Waste Disposal held by the Joint Congressional Committee on Atomic Energy in 1959. (*1*)

The AEC Manual Chapters (*2*), and the recommendations of the Federal Radiation Council (FRC) (*3*), the National Council on Radiation Protection and Measurements (NCRP) (*4*), the International Commission on Radiological Protection (ICRP) (*5*), and the results of Hanford research programs form the basis of radiation protection practices at Hanford. The recommendations of these organizations in the form of permissible rates of intake of specific nuclides and guides for radiation exposure constitute criteria against which radiation exposures estimated from measurements of the Hanford environmental surveillance program are compared. The results of these comparisons indicate the effectiveness of Hanford waste control and radiation protection practices and point out any conditions requiring attention.

This report presents estimates of the annual exposure received by the individuals judged to have received the greatest amount of radiation from environmental sources and the exposure received by people who are considered typical of this region. These exposures are compared with the recommendations of the FRC and NCRP. The Radiation Protection Guides established by the FRC for individuals are 1,500 mrem per year to the thyroid, 1,500 mrem per year to the bone, and 500 mrem to the whole body. The Radiation Protection Guides for the "average of a suitable sample of an exposed population group" are one-third of those for individuals. The NCRP recommendation, in the form of maximum permissible exposures for individuals that are not employed in radiation work are 1,500 mrem/year to the GI tract, 500 mrem/year to the total body, and 3,000 mrem/year to the thyroid. The limits for bone-seeking nuclides are calculated with reference to biological effects observed from deposition of radium and are most readily applied in the form of maximum permissible rates of intake (MPRI).[4]

Environmental conditions

A discussion and interpretation of the results of the several Hanford environmental sampling programs are presented in the following text and tables.

Radionuclides in the Columbia River

Hanford's eight production reactors and the new N-Reactor use Columbia River water for

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[3] Operated during 1964 for the Atomic Energy Commission by the General Electric Company.

[4] The MPRI is taken as the maximum permissible concentration in water for a given radionuclide, as recommended by the NCRP for persons in the neighborhood of controlled areas, multiplied by the rate of water intake defined for the standard man. This amounts to one-tenth of the MPC's for continuous exposure of occupational workers multiplied by 2,200 cc per day, or by 800 liters/year in the case of annual estimates.

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cooling. The new N-Reactor was operated according to a power ascension program during 1964. The old production reactors circulate water once through as a coolant before it is returned to the river, the new reactor uses recirculating demineralized water as a primary coolant. Only a very small amount of radionuclides generated in auxiliary systems, such as the control-rod cooling water, are released to the river. At the old reactors, stable elements present in the cooling water are transformed into radionuclides during passage through the reactors. In addition, radioactive materials formed on the surfaces of fuel elements and channels are eventually carried away by the cooling water to the river. One of the old production reactors, 105–DR, was shut down permanently on December 30, 1964. Two additional reactors, 100–F and 100–H were shut down in April and June 1964, respectively.

Many of the radionuclides formed in reactor cooling water are short-lived and decay rapidly after formation. In addition to radioactive decay, some portion of the radionuclides is removed from the water by sediments and by uptake by aquatic organisms. The radionuclides in the river also include some contribution of fallout from weapons tests.

The sampling program for Columbia River and sanitary water was generally revised during 1964. The major changes were a shift from Pasco to Richland as the principal river monitoring point and a change from occasional "grab" samples to cumulative samples at several locations. Yearly averages, where shown, are weighted averages of the best data available.

Samples of river water were collected above the production areas at Vernita Ferry, and below the production areas at the Richland and Pasco water plant intakes, McNary Dam, the Dalles Dam, and Bonneville Dam. Routine sample collection at Vancouver, Washington, was discontinued during the first half of 1964 and replaced by the Bonneville Dam sampling site. Where possible, cumulative sampling equipment was installed which provided a more representative sample than the infrequent "grab" samples obtained in the past. This sampling technique, however, makes it impractical to calculate the amounts of very short-lived nuclides, and these must still be measured from "grab" samples. The average concentrations of radionuclides measured routinely at Richland, Pasco, and Bonneville Dam are shown in table 1.

Table 1. Annual average concentrations of several radionuclides in Columbia River water–1964

(Units of pCi/liter)

Radionuclides	Richland	Pasco	Bonneville Dam
Total beta	(16 counts/min/ml)	[a] —	—
RE + Y [b]	520	230	—
Sodium-24	3,500	1,500	—
Phosphorus-32	300	200	28
Chromium-51	12,000	6,800	2,400
Copper-64	5,300	2,100	—
Zinc-65	450	240	63
Arsenic-76	1,200	670	—
Strontium-90	1	1	—
Iodine-131	19	12	<5
Neptunium-239	2,600	1,300	—

[a] Dash indicates insufficient sampling data to provide a reasonable annual average.

[b] Rare earths plus yttrium.

Measurements on a traverse across the river at Richland indicated slightly nonuniform distribution of the longer-lived radioisotopes throughout the river at this point. At Pasco, the distribution was also slightly nonuniform primarily because of the entry of the Yakima River some 10 miles upstream. Similarly, the distribution of radionuclides at McNary Dam is influenced by the Snake River whose confluence with the Columbia River is about 30 miles above the dam. The Dalles Dam and Bonneville Dam are approximately 190 miles and 240 miles, respectively, below the Hanford reactors and represent the farthest downstream locations where river water is routinely sampled for Hanford's environmental surveillance program.

There is no known instance of untreated river water being consumed routinely by humans. For comparative purposes, however, the relationship between the concentrations of radionuclides in untreated Columbia River water and "maximum permissible concentrations" in water is shown in table 2. In this instance, the comparison is with the MPC's listed in column 2, table II of annex I of AEC Manual chapter appendix 0524 (*2*). For the most part, these MPC's are equivalent to one-tenth of the most limiting values recommended by the NCRP (*4*) for occupational workers. The marked reduction in percent of MPC_w that occurs with distance downstream from the reactors results principally from radioactive decay of the shorter-lived nuclides.

Table 2. Relationship between the concentrations of radionuclides in untreated Columbia River water and maximum permissible concentrations

Sampling location	MPC, percent [a]
Richland	15
Pasco	7
Bonneville Dam	<1

[a] This is a summation of the percents of MPC's contributed by the several individual radionuclides measured routinely in the river water. The MPC's used and the method of summation are taken from AEC Manual Chapter 0524.

Radionuclides in drinking water

The city of Richland is the first community downstream from the Hanford reactors to use the Columbia River as a source of sanitary water supply. The year 1964 was the first full year of operation for Richland's new water treatment plant. Previously, Richland's sanitary water was obtained from wells, but now these wells are used only during peak demand periods. Pasco and Kennewick, a few miles further downstream, continued to use the Columbia River as a source of sanitary water during 1964. Continuous sanitary water samples were collected at the Richland water plant and periodic sampling was accomplished at Pasco and Kennewick. All of these samples were analyzed for the important individual radionuclides. The results of the radioanalysis of water from these three cities are summarized in table 3.

Table 3. Annual average concentrations of several radionuclides measured in sanitary water–1964

(Units of pCi/liter)

Radionuclides	Richland	Pasco	Kennewick
Total Beta	(10 counts/min/ml)	(3.4 counts/min/ml)	(0.54 counts/min/ml)
RE+Y [a]	70	60	10
Sodium-24	2,500	700	150
Phosphorus-32	40	40	<10
Chromium-51	8,000	6,000	3,000
Copper-64	2,000	400	90
Zinc-65	90	70	<20
Arsenic-76	450	300	<50
Strontium-90	2	1	<0.5
Iodine-131	10	8	<3
Neptunium-239	2,000	450	50

[a] Rare earths plus Neptunium.

The concentrations of short-lived radionuclides in the water at the time it is consumed are less than shown in table 3 because there is a significant flow time between the water plant and most consumers. The flow time may vary from hours to days depending upon the location of the customers on the distribution system and the water demand.

Table 4 shows the apparent removal of several radionuclides by water treatment at Pasco and Richland. These data include the radioactive decay of the short-lived radionuclides during travel through the water treatment plant.

Table 4. Depletion of radionuclides from Columbia River water by treatment at the Richland and Pasco water plants–1964

Radionuclides	Depletion, percent	
	Pasco	Richland
RE+Y [a]	80	90
Copper-64	80	70
Arsenic-76	70	70
Zinc-65	70	80
Phosphorus-32	60	90
Sodium-24	50	30
Neptunium-230	40	30
Chromium-51	10	30

[a] Rare earths plus yttrium.

The calculated annual average dose to the GI tract, total body, and the percentage MPRI for bone from sustained consumption of sanitary water throughout the year at the three cities is presented in table 5.

The dose received by the GI tract of Pasco residents continued at approximately the same level as experienced during 1963. The dose received by the GI tract of Richland residents was somewhat lower in 1964 than was predicted from the initial results obtained following start-up of the new water treatment plant in the latter part of 1963.

Table 5. Calculated annual dose for selected organs from routine ingestion of sanitary water–1964 [a]

Location	Total body, mrem	GI tract, mrem	Bone percent, MPRI	Thyroid (small child, 1 liter/day), mrem
Richland	3.5	50	1	75
Pasco	<2	20	0.8	40
Kennewick	<1	<5	<0.5	<20

[a] Here and elsewhere in this report where a dose from an ingested nuclide is expressed in mrem units, the determination is made from parameters used by the ICRP to translate dose rates into Maximum Permissible Concentrations for drinking water. In most cases, the estimated annual intakes of individual radionuclides were multiplied by conversion factors derived from the ICRP parameters and published by Vennart, et al.(8)

The "standard man" (5) average intake of 1.2 liter/day was used in this calculation.

Radionuclides in fish and waterfowl

The Columbia River is popular for sport fishing both above and below the Hanford plant, and the fish that feed downstream from the reactors acquire some radionuclides from the reactor effluent. Whitefish are the sport fish that usually contain the greatest concentration of radioactive materials, and phosphorus–32 is the radionuclide of greatest significance. Further, they can be caught during winter months when other sports fish are difficult to sample. For these reasons, whitefish are sampled most intensively to follow trends.

Usually the peak concentrations of phosphorus–32 in whitefish occur during the fall months. During 1964, however, below normal river flow rates in the spring, and below normal river temperatures in the fall, resulted in peak concentrations during the first half of the year. The overall effect of these unusual conditions was an annual average concentration in whitefish of about 470 pCi ^{32}P/g and 37 pCi ^{65}Zn/g virtually the same as in 1963. If whitefish were eaten fresh at the rate of one meal per week (about 25 lb/yr), the intake during 1964 would have been approximately 5 μCi of phosphorus–32 and 0.4 μCi of zinc–65. The resulting exposure would have been about 100 mrem to the GI tract, 40 mrem to the total body, and 30 percent of the MPRI for bone. Many of the fishermen that catch whitefish prefer to smoke them, and radioactive decay of the phosphorus–32 (2-week half-life) during storage of the preserved fish reduces the potential intake of this nuclide.

The quantities and kinds of fish caught by local fishermen have been estimated previously from surveys carried out by personnel of the State of Washington, Department of Game, and no additional dietary data were collected during 1964 that would change these estimates. Those individuals who probably ingest the largest amounts of phosphorus–32 are fishermen who claim to eat bass, crappie, perch, and catfish as often as 3 to 5 times a week. This number of fish meals indicates an annual intake of about 90 pounds of fish. Analyses of these species of fish from locations fishermen claimed to visit most frequently indicated no peak concentration in the spring and generally lower phosphorus–32 concentrations than found in whitefish (used as reference for estimating dose in the preceding paragraph). On the basis of the 90 pounds of fish consumption claimed by the "maximum individual," (approximately 200 fish meals/year), the intake of phosphorus–32 during 1964 could have been approximately 3 μCi.

Many persons have been counted in the Hanford whole body counter, including some avid fishermen. Amounts of zinc–65 detected in these people were much less than expected on the basis of their stated fish consumption. These results supported the findings of 1963 which suggested that fishermen tend to overestimate their fish consumption. Therefore, the actual ingestion rates of both phosphorus–32 and zinc–65 are substantially lower than postulated from the fishermen's estimates.

Migratory waterfowl, such as ducks and geese, that have utilized the Hanford section of the Columbia River and the swamps and ponds within the project boundaries may contain phosphorus–32, zinc–65, and other radionuclides. Some of these waterfowl remain in this general area throughout the year. One hundred and forty-seven samples were collected during the hunting season within the Hanford project and in the environs, and 71 samples were contributed by hunters from areas adjacent to the plant.

Only five samples contributed by hunters contained concentrations of phosphorus–32 greater than the detectable level of 50 pCi/g of flesh (wet weight), and the highest concentration found was 650 pCi/g. Of all waterfowl samples collected in the Hanford environs, about one-third contained detectable levels of phosphorus–32 and about one in ten contained 500 pCi/g or greater. The maximum concentration measured during the hunting season was 1,700 pCi ^{32}P/g of flesh.

Radionuclides in marine organisms

Zinc–65 and phosphorus–32 are the only radionuclides in the reactor effluent that are found in sufficient abundance beyond the mouth of the Columbia River to be of radiological interest. Oysters have been found to contain higher concentrations of zinc–65 than other common seafood organisms. Concentrations of zinc–65 have gradually decreased over the past 2 years while phosphorus–32 concentrations have remained at about the same level. The average concentrations in samples taken periodically throughout the year were 56 pCi ^{65}Zn/g and 4 pCi ^{32}P/g. Consumption of oysters containing these concentrations at the rate of one meal per week (one-half pound) would result in an annual exposure of about 7 mrem to the GI tract, 4 mrem to the whole body, and about 0.5 percent of the MPRI for bone.

Radionuclides in the atmosphere

At Hanford, gaseous waste from the chemical separations facilities is released to the atmosphere through 200-foot high stacks after most of the radioactive materials have been removed by filters and scrubbers. These radioactive materials are primarily associated with process off-gases. Ventilation air from laboratory and reactor buildings contains comparatively minor amounts of radioactive materials under normal operating conditions.

Iodine–131 is the radionuclide of principal interest in the separations facilities process off-gases. Gross beta measurements are continuously made to detect any change in emission rates of other radionuclides. The results for the past 4 years are summarized in table 6.

Table 6. Annual average emission rates of several radionuclides from separations plant stacks

(curie/day)

Radionuclide	1964	1963	1962	1961
Iodine-131	0.22	0.38	0.35	0.7
Zirconium-niobium-95	[a] —	—	0.0024	0.005
Ruthenium-103	—	—	0.0009	0.003
Ruthenium-106	—	—	0.0036	0.005
Cerium-141	—	—	0.0002	0.006
Cerium-144	—	—	0.015	0.01
Filterable gross beta	0.030	0.013	—	—

[a] Dash indicates insufficient sampling data to provide a reasonable annual average.

The fission product recovery facilities operating at Hanford contributed negligible amounts of radionuclides to the environs during 1964. The average emission rate of strontium–90 from these facilities was less than 0.002 Ci/day.

Measurements of airborne iodine–131 were made routinely at several locations within the Hanford reservation and at several locations around the plant perimeter. The results of iodine–131 measurements for the past few years are summarized in table 7.

The four locations listed in table 7 lie within a 45 degree sector southeast to south of the separations center. The annual average concentrations of iodine–131 in air about the Hanford plant during 1964 were generally 0.05 pCi/m^3 or less. Such concentrations sustained in inspired air imply an annual dose to the thyroid of the "standard man" of less than 1 mrem.

Table 7. Average iodine-131 concentrations in the atmosphere

(Units of pCi/m^3)

Location	Distance from separation stacks, miles	1964	1963	1962	1961
Benton City	20	0.06	0.03	0.08	0.02
Prosser Barricade [a]	14	0.02	—	—	—
Richland	23	0.02	0.02	0.04	0.02
Pasco	32	0.01	0.02	0.08	0.04

[a] Installed during October 1963.

[b] Dash indicates insufficient sampling data to provide a reasonable annual average.

Air sampling stations are maintained at several locations within the Hanford reservation and at several locations situated around the plant perimeter. Early in 1964 the remote sampling stations (Boise and Lewiston, Idaho; Klamath Falls and Meacham, Oregon; Great Falls, Montana; and Seattle, Washington) were discontinued and replaced by stations forming a closer ring about the perimeter of the Hanford reservation. The sampling stations now in operation include Pendleton and McNary Dam, Oregon; Spokane, Walla Walla, Yakima, Moses Lake, Ellensburg, Wenatchee, Sunnyside, and Washtucna, Washington. During the early part of 1964 beta activity on air filters was less than 1 pCi beta/m^3 but increased to about 3 pCi beta/m^3 in May during the spring influx of worldwide fallout. The airborne activity then decreased steadily to less than 1 pCi beta/m^3 except for a very brief period at the end of October when fallout from the Chinese nuclear test caused a slight increase.

Results of air filter measurements are not used in estimating exposure but serve to illustrate the trends in atmospheric contamination. Sudden changes in concentration are used to signal the need for shifted emphasis in other portions of the environmental monitoring program related to atmospheric contamination.

Radionuclides in milk and produce

The radioactivity found in locally grown agricultural produce can be influenced by deposition of airborne radionuclides, or by irrigation with river water containing reactor effluent radionuclides. The chemical separations facilities are generally considered to be the principal local source of airborne radionuclides. Ventilation stacks of the reactors or laboratory facilities possibly could, under certain conditions, become of some small interest. The closest farming area to the separations facilities is about 13 miles away.

Most irrigated farms near the Hanford plant use water from the Yakima River, or from the Columbia River above the project. There are, however, two small areas which take water regularly from the Columbia River downstream from the reactors for irrigation. They are the Ringold farms and the Riverview district west of Pasco located 15 and 30 miles, respectively, downstream from the reactors. The Ringold farms, approximately 13 miles east of the production areas involve about 20 people working some 500 acres of land with fruit as the principal product. The Riverview farm area consists of about 5,300 acres supporting about 1000 families, the majority of which live on plots of an acre or less and raise family gardens. The principal products from the larger farm plots are hay, fruit, beef, and dairy products. This area is located 30 miles southeast of the chemical separations plants. Another agricultural area near the project is Benton City, located on the Yakima River about 20 miles directly south of the separations facilities.

A comprehensive milk surveillance program maintained during 1964 included samples from local farms and dairies and from commercial supplies available to people in the Tri-Cities. The concentrations of radionuclides found in milk sold by commercial outlets were similar to those reported by the U.S. Public Health Service and the Washington State Department of Health. Milk from local farms irrigated with water from the river downstream from the reactors contained phosphorus–32 and zinc–65, as well as several fission products of fallout origin.

The average concentration of iodine–131 in both local and commerical milk was at or below the reporting limit of 3 pCi/liter except for a brief increase during the summer months and again briefly following the Chinese nuclear test in the fall. The maximum concentration of iodine–131 observed in milk was 36 pCi/liter on November 10, 1964. Activity levels then decreased rapidly in December to 3 pCi/liter or less.

Concentrations of strontium–90 measured in milk produced locally ranged from less than 2 pCi/liter to 16 pCi/liter. These values are similar to concentrations found in commercial milk produced in areas that are remote from the Hanford plant. Strontium–90 found in milk from local farms averaged about 8 pCi/liter, and a generally decreasing trend was observed throughout the year. Concentrations of strontium–90 and cesium–137 in milk analyzed at Hanford were generally at or below the detection levels of 2 pCi ^{90}Sr/liter and 30 pCi ^{137}Cs/liter. Worldwide fallout is the principal source of these radionuclides in milk.

Dairy farms in the Ringold and Riverview area that utilize the Columbia River for irrigation of pasture land and hay fields produce milk containing both phosphorus–32 and zinc–65. During 1964 the average concentration of phosphorus–32 in milk from these farms was about 1,600 pCi/liter and the concentration of zinc–65 was 550 pCi/liter. The highest concentration of phosphorus–32 in milk (5,700 pCi/liter) was observed during August, a period of heavy irrigation and rapid growth of pasture grass. Commercial milk distributed in the Tri-Cities usually does not contain phophorus–32 and zinc–65 because it is obtained principally from areas not irrigated with Columbia River water.

If the commercially available milk were consumed at the rate of 1 liter/day, the "fallout" radionuclides would contribute an annual average dose of less than 1 mrem to the GI tract, about 4 mrem to the total body, and about 3 percent of the FRC rate of intake guide for bone.[5] Residents consuming milk obtained from the Ringold-Riverview area would receive some additional exposure from phosphorus–32 and zinc–65 amounting to about 12 mrem to the GI tract, 5 mrem to the total body, and about 4 percent of the MPRI for bone.

Miscellaneous fresh farm produce was sampled periodically during the 1964 growing season from local farms and commercial outlets for radioanalysis. Results of these measurements were similar to those of previous years and indicated that only small quantities of radionuclides are present in locally grown products.

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[5] The Federal Radiation Council does not consider fallout from the testing of weapons to be from "normal peacetime operations" for which the Radiation Protection Guides were developed.

The concentrations of iodine–131 found on samples of fresh vegetables collected from local farms and markets during the period of May through September were less than or approximately at the detection level of 0.05 pCi/g. There was no significant difference noted in concentrations found on local farm produce and on produce purchased from commercial outlets. If these fresh vegetables had been consumed at the rate of 100 g/day throughout the 5-month growing season, the average annual intake from this source would have been about 750 pCi ^{131}I. Such an intake would imply an annual exposure of about 1 mrem to the thyroid of a "standard man".

Concentrations of iodine–131 in cattle thyroids

The thyroids of cattle are collected periodically from slaughter houses by cooperating veterinarians in Moses Lake, Toppenish, Walla Walla, Wenatchee, and Pasco and sent to Hanford for radioanalysis. Since the concentration of iodine–131 in bovine thyroids is about two orders of magnitude higher than that in the pasture grass or in milk, it is advantageous to use thyroid measurements to follow probable trends in concentrations of iodine–131 in milk and farm produce when the levels in milk and vegetables are too low for practical measurement. The average concentrations measured in beef thyroids were generally at or below the reporting level of 5 pCi ^{131}I/g during most of 1964 except for brief periods in the summer and again following the Chinese nuclear test on October 16. The maximum concentration observed in November was only 60 pCi ^{131}I/g from one sample collected at Pasco. By the end of the year concentrations of iodine–131 in beef thyroids were again near the reporting level of 5 pCi/g.

External radiation

Ionization chambers are stationed on the Hanford reservation and are submerged in the Columbia River to estimate the gamma radiation doses from external sources. Measurements in air over the ground during 1964 averaged about 0.41 mR/day or 105 mR/year, somewhat lower than measured during the past 2 years. Essentially, all of this exposure is from natural background and worldwide fallout from nuclear testing.

Direct radiation measurements are made in the Columbia River at several locations with pocket-type ionization chambers submerged 2 to 5 feet below the surface of the water. Exposure rates are higher in the river than over ground because of the presence of gamma emitters, especially sodium–24, in reactor effluent. In the vicinity of Pasco and Richland the average dose rates in the water during the months of April through October were about 1.5 and 2 mR/day, respectively. A person swimming or boating in the river for a total of 240 hours during the year would receive about 15 mR total body exposure near Pasco and about 20 mR near Richland.

Radiation measurements (*9*) made along the shoreline of the river indicate the exposure rate may be about 0.25 mR/hour from radionuclides deposited with debris and in the mud and sand by fluctuating water levels. If an ardent fisherman were to spend as many as 200 hours fishing along the river's edge, the annual whole body exposure received from these materials would be about 50 mR.

An aerial radiation surveillance program conducted during 1964 included several flight patterns both over the Hanford reservation and the surrounding area. Background gamma radiation measurements were made during these flights over the predesignated ground check points for comparison with previous measurements. No significant changes in radiation levels were detected over the ground covered by these flight patterns.

Radioactive wastes released to ground

Liquid wastes from the chemical separations area are routed to various facilities dependent upon their burden of radionuclides. High level wastes (normally containing concentrations greater than 100 μCi/ml) are stored in underground concrete tanks lined with steel. Intermediate level wastes, ordinarily containing concentrations in the range of 5×10^{-5} μCi/ml to 100 μCi/ml, are sent to underground "cribs" from which they percolate into the soil. The areas selected for intermediate waste disposal and high level waste storage have soil with good ion exchange capacity and depths of 150 to 350 feet to ground water. Low level wastes usually containing less than 10^{-5} μCi/ml are sent to depressions in the ground where surface

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ponds or "swamps" have been formed as a result of the continuous addition of the relatively large volumes of water.

One important objective in the management of wastes placed in the ground is the prevention of radiologically important radionuclides from reaching the ground water in quantities that could ultimately cause significant human exposure should they migrate to the Columbia River. For this reason wells have been drilled in and around crib and tank storage areas to detect any leaks in the tanks and for measuring radionuclides that have reached the ground water. Virtually all of the radionuclides present in the ground water have been introduced with liquids sent to the cribs.

The quantity of radioactive material sent to ground during 1964 (excluding tritium and materials sent to storage tanks) was about 155,000 curies. This is a considerably greater quantity than is normally discharged during a 12-month period and was primarily caused by an accidental discharge of approximately 100,000 curies of fission products to a specific retention facility and a process equipment failure which allowed approximately 10,000 curies to be discharged to an open pond. Neither release will cause significant ground water contamination. The historical total of radioactive materials sent to ground is estimated to be approximately 2,800,000 curies. Because of radioactive decay, the current total is estimated to be only 300,000 curies. In order of abundance, the bulk of the material is ruthenium–106, cesium–137, and strontium–90.

The detectable beta contamination (not including tritium) in the ground water beneath the 200 W Area was less extensive in 1964 than in previous years. This resulted from a reduction in the amount of contaminants discharged to ground, radioactive decay, and further dilution in the ground water.

A substantial amount of tritium has been sent to the ground with the intermediate level liquid wastes from the separations plants.

In all probability, some tritium and ruthenium–106 originating at the chemical processing areas is now entering the Columbia River. However, the contribution of these nuclides is too small to be detectable in the river water and any exposure from them is negligible.

Radiation exposure

It is not possible to determine the precise radiation exposure received by every individual because of variations in the kind and quantity of food consumed, sources of food supply, and many variations in personal living habits. These inherent variations between individuals require a somewhat subjective approach when estimating the probable radiation exposure in relation to various established limits. The Federal Radiation Council has provided two sets of guides against which exposures from environmental sources may be judged, *i.e.*, one for the individuals that received the greatest exposure, and the other for the average exposure received by the general population (taken as one-third of that set for individuals). For the Hanford environs, exposures from the various sources described in the preceding sections have been compiled in two ways to allow comparisons with guides for both the individual and the general population. In one case a hypothetical, but plausible, individual has been assigned dietary and other habits that would result in what would seem to be the greatest rational exposure. For the general population, an exposure has been estimated for what is called the "average" Tri-City resident. Some residents may receive more exposure than calculated for the "average" Tri-City resident, but very few, if any, receive as much as that calculated for the "maximum" individual. Included in this intermediate group are families that subsist largely on foodstuffs produced on farms irrigated with water taken from the Columbia River downstream from the reactors.

The maximum individual

Attempts have been continued to identify the individuals living in the Hanford environs that receive the greatest exposure. Experience accumulated from the environmental surveillance program indicates such individuals are undoubtedly persons that frequently eat fish caught locally in the Columbia River and foodstuffs grown on farms irrigated with Columbia River water. Additional data collected during 1964 continued to support the assumption that fish, consisting mainly of crappie, perch, bass, and catfish caught near Burbank are the most important source of radionuclides for the "maximum" individual. On the basis of an assumed consumption of 200 meals per year and radiochemical analyses of such fish, the intake of phosphorus–32 for the "maximum" individual during 1964 would have amounted to about 3 μCi (about 20 percent of the NCRP

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limit). Whether this amount of fish was actually eaten by the individual was not confirmed. However, other persons reporting an unusually high consumption of local fish were counted in the whole body counter and were found to have far less zinc-65 deposited than predicted on the basis of estimates of the quantities of fish eaten.

A maximum reported consumption of 200 meals/year is used as a basis for calculating the intake of radionuclides from this source. The consumption rates of other foods for the hypothetical "maximum" individual are based on the maximum intakes described in various dietary surveys. It is assumed that this individual consumes each day over 2 quarts of water from the Pasco system, and about 1 quart of milk, ½ pound of beef, and nearly ½ pound of fresh leafy vegetables (in season), all produced on river-irrigated farms in the Riverview District. The exposure amounts to about 10 percent of the appropriate limit for the GI tract, 25 percent of the limit for bone, 1 percent of the limit for the thyroid, and 20 percent of the limit for the total body. Included with the estimate of total body exposure is 50 mR received from the river bank while fishing. The estimated exposure to the total body from strontium-90 is more than was actually received because the method of calculation assumes that the rate of intake experienced in 1964 had been sustained for many years.

In the case of the thyroid gland, it is possible that the maximum exposure occurred in small children because of the relatively small thyroid mass in which the iodine-131 accumulates. The thyroid of a small child is assumed to weigh 2 grams compared with 20 grams for the adult. On the basis of a daily intake of 1 liter of milk, 50 grams of fresh, leafy vegetables produced in the Riverview District, and 0.8 liter of water from the Pasco system, the estimated annual intake of iodine-131 was about 4,400 pCi for a small child in 1964. Such an intake would result in a thyroid dose of 75 mrem or 5 percent of the FRC Radiation Protection Guide for individuals.

The average Tri-City resident

The vast majority of people who live in Richland, Pasco, and Kennewick obtain their food from local commercial stores (rather than directly from farms) and consume little or no fish caught from the Columbia River. The principal sources of radionuclides to these people are worldwide fallout and drinking water from the Columbia River. It is assumed that the contribution from fallout of iodine-131 and strontium-90 is the same in all three cities. The intake of strontium-90 is estimated with the use of data obtained from dietary surveys made elsewhere in the United States and reported by the Federal Radiation Council, (*3*) but adjusted on the basis of the concentration in milk sold in local stores during 1964. The estimated annual intake of strontium-90 during 1964 was about 0.006 μCi, approximately 8 percent of the FRC guide for the general population exposed to strontium-90 from normal peacetime sources.

The contribution from Hanford-created radionuclides in drinking water is substantially different for the three cities as discussed previously. In Richland, the GI tract exposure was greater than in the cities further downriver because the short-lived nuclides are in greater abundance. As shown in table 5, the estimated exposure for 1964 was about 50 mrem or 10 percent of the population limit. This exposure is significantly below that predicted on the basis of data collected in the last quarter of 1963 following startup of the new water treatment plant. The contribution to the GI tract dose from other sources was relatively insignificant and, conversely, the concentration of bone seekers, such as phosphorus-32 and strontium-90, in water was so low that drinking water did not contribute any significant dose to the bone.

For dose to the thyroid gland, the most appropriate sample of the exposed population would appear to be small children living in Richland who drank water from the municipal system (0.4 liter/day), milk (0.6 liter/day) obtained from the local stores, and fresh vegetables (25 g/day) obtained from local markets. The total intake of iodine-131 during the year from these sources would be about 2,600 pCi or an average of about 7 pCi/day. This is in the middle of the FRC Range I.

The estimated total body exposure of the average Richland resident from artificial radionuclides was about 12 mrem, the major portion of which was assigned to strontium-90 from fallout. The method used to calculate the dose

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from strontium-90 yields a value that is unrealistically high, however, because the parameters used are based on equilibrium conditions which would exist in the body only after many years of ingesting strontium-90 at the rate estimated for 1964. The contribution to total dose by nuclides of Hanford origin (principally sodium-24 and zinc-65) ingested mainly with drinking water was estimated at about 3 mrem. This total body exposure may be compared with the FRC guide of 170 mrem for the average of a suitable sample of an exposed population. Exposure from natural background sources (excluded from the FRC guide) in this region is estimated at about 150 mrem/year.

Conclusions

During 1964 the environmental surveillance program of the Hanford environs again showed that the amounts of radioactive materials present were well within nationally accepted limits at all times, and that releases of radioactive wastes were well controlled.

Phosphorus-32 released to the Columbia River in reactor effluent continued to be the most significant source of exposure from the Hanford project. This phosphorus-32 is concentrated by fish that inhabit the river downstream from the reactors. Individuals who regularly eat such fish as a major part of their diet throughout the year could conceivably have taken in as much as 20 percent of the annual permissible amount of this bone seeker. Other foods, such as milk, and other nuclides, such as strontium-90 from fallout could have increased the total intake of bone seekers by this "maximum individual" to as much as 25 percent of the annual limit. The use of similar dietary assumption last year resulted in an estimate of 50 percent for 1963.

There were no unusual releases of radionuclides from the Hanford plants during 1964 that warranted special assessment of the radiation dose to persons in the environs. The deposition of strontium-90 from worldwide fallout was significantly less in 1964 than in 1962 or 1963 and, consequently, this nuclide contributed less exposure.

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Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
1959 and first and second quarters of 1960	*May 1961*
Third and fourth quarters 1960 and first and second quarters 1961	*February 1962*
Third and fourth quarters 1961	*October 1962*
Calendar year 1962	*January 1964*
Calendar year 1963	*January 1965*

2. Pinellas Peninsula Plant
January–June 1965[6]

General Electric Company
St. Petersburg, Florida

Pinellas Peninsula Plant, shown in figure 2, is an electronic component production facility. The plant maintains an environmental monitoring program to measure the levels of radioactive environmental contamination associated with plant effluents. These measurements serve as an index of the effectiveness of the plant's contamination control measures. Environmental monitoring includes sampling of a single combined sewer effluent, milk from three local dairy farms, and air and surface water obtained at locations suggested by meteorological conditions and radioactivity discharge concentrations. Except for air samples, which may also contain tritium gas, the radioactive portion of the samples is essentially tritium oxide.

Air monitoring

Air samples are obtained periodically in areas up to 2 miles downwind from the exhaust stack. Analysis of the one sample collected during the sampling period revealed no detectable amounts of tritium gas or tritium oxide. The limit of detection is 9,600,000 pCi/m^3 for tritium gas and 5,000 pCi/m^3 for tritium oxide.

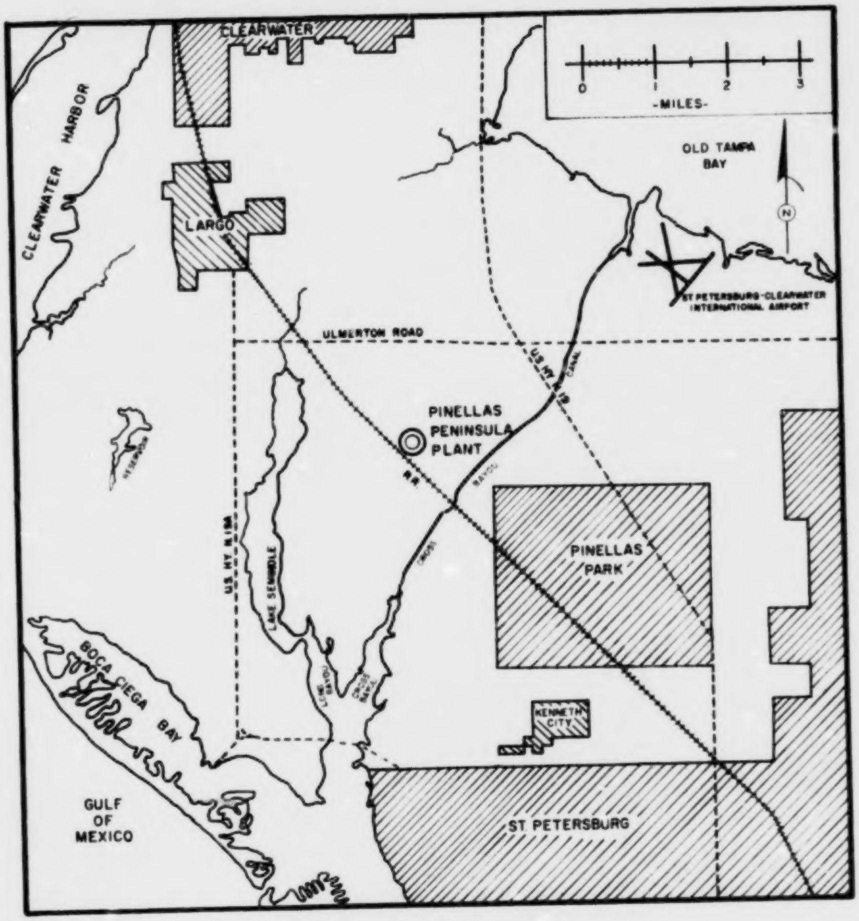
CLEARWATER
CLEARWATER HARBOR
LARGO
0
1
2
3
-MILES-
OLD TAMPA BAY
N
ST PETERSBURG-CLEARWATER INTERNATIONAL AIRPORT
ULMERTON ROAD
US HY 19
CANAL
PINELLAS PENINSULA PLANT
RR
BAYOU
CROSS
US HY ALT 19
LAKE SEMINOLE
PINELLAS PARK
BOCA CIEGA BAY
LONG BAYOU
CROSS BAYOU
KENNETH CITY
GULF OF MEXICO
ST PETERSBURG

Figure 2. Location of the Pinellas Peninsula Plant

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[6] Summarized from "Environmental Monitoring, January 1 through June 30, 1965", General Electric Company, Pinellas Peninsula Plant, St. Petersburg, Florida.

Sewer effluent monitoring

A combined sewer effluent sample is obtained daily near the perimeter of the plant's property. During the sampling period 5 of 125 samples analyzed showed detectable concentrations of tritium (>90,000 pCi/liter).[7] The maximum concentration, 630,000 pCi/liter, was caused by radioactivity in the cooling water discharged from the plant's incinerator during the burning of low level contaminated wastes. Calculations based on radioactivity releases from the process waste system, the incinerator, and the plant's water discharges, indicate that the average tritium concentration in the combined sewer effluent for the first half of 1965 was less than 1.52 percent of the radioactivity concentration guide for continuous non-occupation exposure.

Surface water sampling

Surface water samples are collected at monthly intervals at selected locations within 8 miles of the plant. The sampling areas are determined by interrelating the concentrations of radioactivity in exhaust stack effluent with meteorological data. There were no indications of tritium oxide (>90,000 pCi/liter) in the 46 surface water samples analyzed during the sampling period.

Milk sampling results

Fifteen samples of raw milk were collected from farms within a 3-mile radius of the plant. These samples were analyzed by the Florida State Board of Health during 1965. No detectable concentrations (>90,000 pCi/liter) of tritium oxide were evident.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
1960–1961	*July 1962*
Calendar year 1962	*June 1963*
Calendar year 1963	*September 1964*
January–June 1964	*February 1965*
July–December 1964	*August 1965*

3. Savannah River Plant[8]
January–June 1965

E.I. du Pont de Nemours
Aiken, South Carolina

The Savannah River Plant (SRP), built and operated for the Atomic Energy Commission by E. I. du Pont de Nemours and Company, occupies an area of 312 square miles along the Savannah River, 22 miles downstream from Augusta, Georgia. Production facilities include a fuel preparation area, four operating reactors, two fuel separation areas, and a heavy water production plant. The fifth production reactor and the heavy water component test reactor were closed down permanently in 1964. A basic goal in plant operation is total containment of radioactive waste. Although some very low level gaseous and liquid wastes are discharged to the environment in controlled releases, dispersal is adequate to insure environmental concentrations below recommended guides.

The DuPont environmental monitoring group has maintained a continuous monitoring program since 1951 (prior to plant startup) to determine the concentrations of radioactive materials in a 1,200-square-mile area outside the plant. This surveillance determines the magnitude and origin of any radioactivity above natural levels. Measured concentrations of radionuclides in air, water, and milk are compared with the maximum permissible concentrations (MPC) in the AEC Manual (see footnote 1, page 113).

Sensitive instruments, which can detect traces of radioactive materials far below concentrations of hazard significance, are used to determine radioactivity in the environs. Maximum and minimum values given are for individual samples collected during the reporting period.

Atmospheric monitoring

Concentrations of radioactive materials in the atmosphere were measured by weekly analyses of air filters collected at five monitoring stations located on the plant perimeter and nine stations around a circle of about 25 miles radius from the center of the plant (figure 3).

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[7] Expressions in parentheses indicate limits of detectability in the respective environmental samples.

[8] Summarized from "Effect of the Savannah River Plant on Environmental Radioactivity, Semiannual Report, January–June 1965." (DPST-65-30-2).

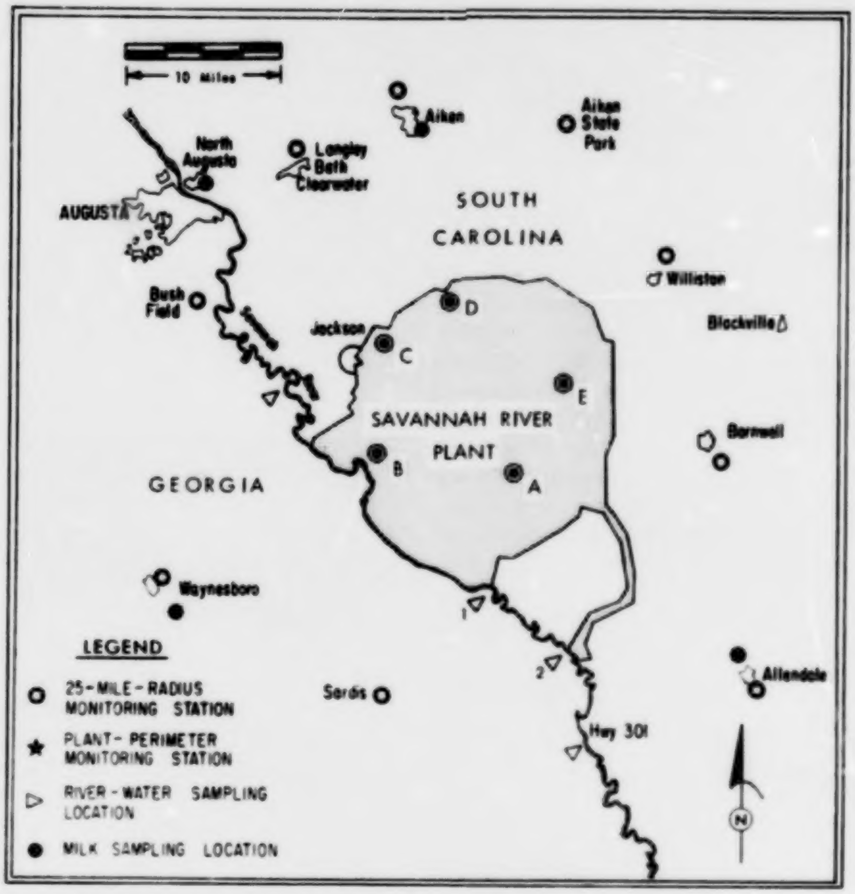
10 Miles
North Augusta
AUGUSTA
Aiken
Langley
Bath
Clearwater
Aiken
State
Park
SOUTH
CAROLINA
Williston
Blackville
Bush
Field
Jackson
D
C
E
SAVANNAH RIVER
PLANT
Barnwell
B
A
GEORGIA
Waynesboro
1
2
Allendale
Sardis
Hwy 301
N
LEGEND
25-MILE-RADIUS MONITORING STATION
PLANT-PERIMETER MONITORING STATION
RIVER-WATER SAMPLING LOCATION
MILK SAMPLING LOCATION

Figure 3. Environmental sampling locations, Savannah River Plant

Deposition rates of radioactive materials at each station were also determined by monthly analyses of rainwater ion exchange columns (fallout collectors). The monitoring stations are spaced so that a significant plant release of airborne activity would be detected regardless of the prevailing wind. All stations operate continuously. Four additional air monitoring stations at Savannah and Macon, Georgia, and at Columbia and Greenville, South Carolina, are so distant from the plant that the effect of SRP operations is negligible; they are reference points for determining background activity levels (figure 4). This system permits comprehensive surveillance of atmospheric radioactivity and also makes it possible to differentiate between weapons test fallout and plant releases.

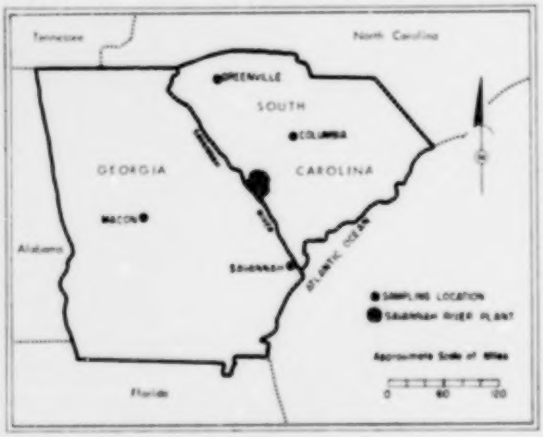
Tennessee
North Carolina
GREENVILLE
SOUTH
COLUMBIA
GEORGIA
CAROLINA
MACON
Alabama
SAVANNAH
ATLANTIC OCEAN
SAMPLING LOCATION
SAVANNAH RIVER PLANT
Approximate Scale of Miles
0
60
120
Florida

Figure 4. Distant air monitoring stations, Savannah River Plant

The small amount of radioactive materials released to the atmosphere from the fuel separation areas was obscured by fallout from nuclear weapons tests. Fallout from the Chinese nuclear detonation of May 14, 1965, was detected in the atmosphere at SRP on May 27. Although the increase in daily measurements of beta activity (from 0.2 pCi/m^3) was small compared to the levels observed after the Chinese test in October 1964 (2.4 pCi/m^3, daily maximum), the presence of short radioactive half-life barium-140 and lanthanum-140 on high volume air samples confirmed the presence of fresh fission products. The influence of the weapons test which resumed in September 1961 is shown in figure 5. Even though the atmospheric weapons test moratorium began in December 1962, airborne radioactivity continued to remain above the pre-September 1961 concentrations. The rises in early 1964 and 1965 were the result of the anticipated spring increase in the mixing of stratospheric debris into the troposphere. The Chinese nuclear test in mid-May contributed slightly to the June 1965 level.

Radioactivity in air, determined from filter analyses, is shown in table 8. The January–June 1965 concentrations of filterable beta activity (0.22 pCi/m^3), and alpha activity (0.0007 pCi/m^3) in air were 0.2 percent and 1.8 percent of their respective MPC's. Iodine-131 concentrations in air samples were less than 0.02 pCi/m^3, the lower detection limit throughout the entire period. The relative abundance of airborne radionuclides since January 1963 is shown in figure 6. The diminishing activity is proportional to the areas of the circles (and circle segments) which show average activity for each 6-month period. Tritium oxide concentrations in air were measured continuously at the plant perimeter and at the 25-mile stations; the average concentration did not exceed 2 percent of the MPC.

Deposition of radioactive materials during the first half of 1965 totaled 56 mCi/mi^2 at plant perimeter locations and 64 mCi/mi^2 at the 25-mile radius locations; comparable values for the last half of 1964 were 69 mCi/mi^2 and 65 mCi/mi^2, respectively. Deposition at each sampling location is recorded in table 9.

Vegetation

Radioactive contamination of vegetation may result from direct deposition on exposed surfaces or absorption of radioactivity from the soil. Bermuda grass was selected for analysis because of its importance as a pasture grass for dairy herds and its availability during all seasons of the year.

Grass samples were collected at seven locations along the plant perimeter and at 7 other

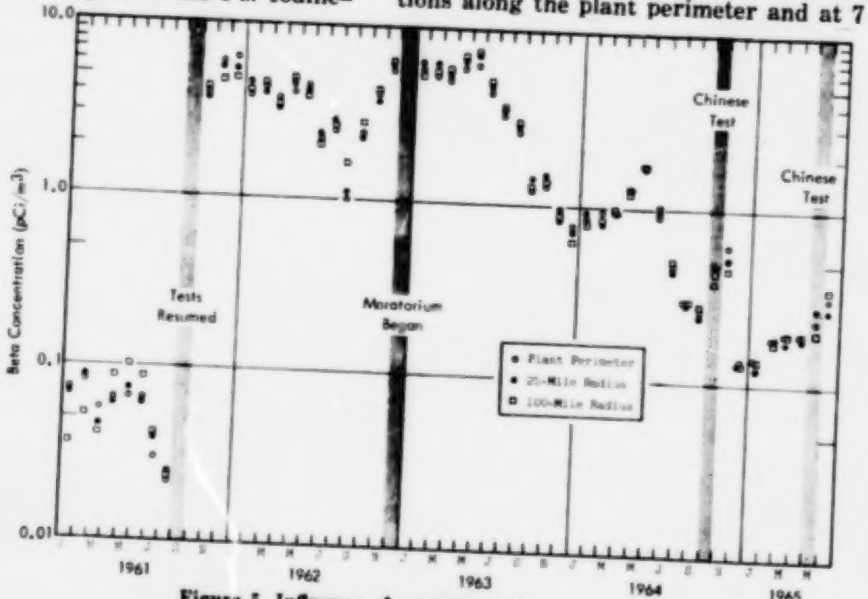

Figure 5. Influence of weapons tests

Table 8. Radioactivity in air, pCi/m^3

(Filter analyses)

	Plant-perimeter locations						Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Average
	A	B	C	D	E	Average										
Alpha emitters in air [a] (multiply by 10^{-3})																
Maximum	1.4	1.8	1.8	1.1	1.8		1.5	1.1	1.5	2.5	1.1	1.8	1.7	2.0	5.4	
Minimum	0.3	0.4	0.3	ND	ND		0.3	ND	ND	0.3	ND	0.3	ND	0.3	ND	
Average	0.7	0.9	0.8	0.6	0.6	0.7	0.8	0.6	0.7	0.9	0.5	0.9	0.7	0.7	0.8	0.7
Nonvolatile beta emitters in air [b]																
Maximum	0.49	0.50	0.48	0.43	0.46		0.36	0.47	0.55	0.47	0.53	0.52	0.69	0.55	0.50	
Minimum	0.01	0.09	0.11	0.11	0.10		0.05	0.08	0.13	0.03	0.05	0.09	0.10	0.11	0.10	
Average	0.24	0.24	0.23	0.22	0.23	0.23	0.20	0.21	0.23	0.19	0.20	0.21	0.22	0.23	0.21	0.21
Specific radionuclides in air (averages)																
Cesium-137	0.02						0.02									
Cerium-144	0.04						0.05 25-miles									
Ruthenium-106	0.03						0.03 radius									
Zirconium-Niobium-95	<0.01						<0.01 composite									
Manganese-54	<0.01						0.01									

[a] Sensitivity of analysis, 0.3 pCi/m^3; MPC, 40 pCi/m^3.
[b] Sensitivity of analysis, 0.006 pCi/m^3; MPC, 100 pCi/m^3.
[c] ND, less than sensitivity of analysis.

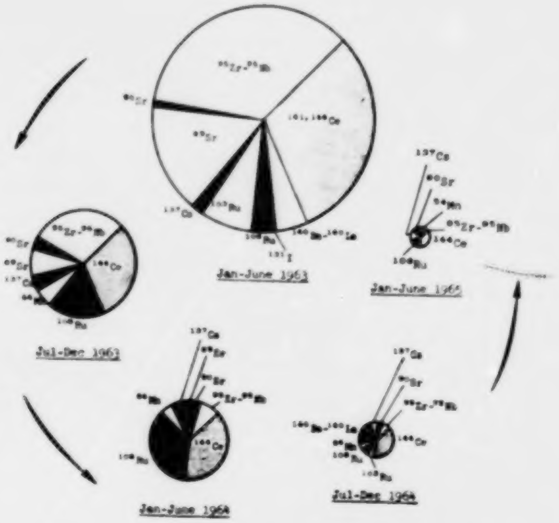

Figure 6. Relative abundance of airborne radionuclides (weapons test fallout)

Table 9. Total fallout deposited, mCi/mi^2

Radionuclides	Plant perimeter locations						25-mile radius locations									
	A	B	C	D	E	Average	Aiken Airport	Aiken State park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Average
Alpha [a]	4.1	8.7	11.1	7.9	9.0	8.2	11.3	6.0	7.6	7.1	12.0	7.1	8.1	5.8	5.8	7.9
Strontium-90	6	8	10	10	8	8	12	9	10	7	9	11	8	9	7	9
Cesium-137	8	9	10	10	8	9	12	8	10	8	9	11	9	8	8	9
Cerium-144	9	15	26	24	19	19	36	15	19	17	31	22	16	20	12	21
Ruthenium-106	8	13	20	20	14	15	34	16	13	14	25	17	16	16	14	18
Zirconium-Niobium-95	2	2	2	3	2	2	5	2	3	3	7	2	3	2	2	3
Manganese-54	3	3	3	3	3	3	5	5	3	4	8	4	4	3	3	4

[a] Multiply by 10^{-3}.

locations along a 25-mile radius route. (These are not designated on figure 3). Samples from each quadrant of the plant and of the surrounding area were composited for weekly analysis. Radionuclides in grass samples were from weapons test fallout. Alpha emitters averaged 0.2 pCi/gram at plant perimeter and 25-mile radius locations; gamma emitters averaged 64 pCi/gram and 40 pCi/gram, respectively. Radionuclide concentrations comprising gamma activity are presented in table 10. While the exact nature of the alpha activity increase is not known, the change is commensurate with previously observed changes which appear to be seasonal. The gamma activity levels were essentially the same as during July–December 1964.

Table 10. Radioactivity on vegetation, pCi/g

	Alpha	^{137}Cs	^{144}Ce	^{106}Ru	^{95}Zr-Nb	^{54}Mn
Sensitivity of analysis	0.10	0.07	0.32	0.45	0.06	0.05
Plant perimenter (7 locations)						
Maximum	0.70	16	59	16	1	4
Average	0.23	11	42	7	1	3
25-mile radius (7 locations)						
Maximum	0.53	9	37	16	2	3
Average	0.20	6	25	6	1	2

Milk

Milk was sampled at four dairies within a 25-mile radius of the plant as shown in figure 3. Samples were taken weekly and analyzed for tritium, iodine–131, and cesium–137. Strontium–90 determinations were made quarterly. Milk produced in the area and sold by major distributors was also analyzed for these radionuclides. Results from analyzing milk for radioactivity during January–June 1965 are given in table 11.

The average concentrations of three radionuclides in milk (36 pCi/liter for strontium–90, <5pCi/ liter for iodine–131, and 81 pCi/liter for cesium–137) were consistent with values reported by the U.S. Public Health Service for most sections of the United States. Tritium in local milk, when present, is assumed to be associated with plant operations. The average tritium level was less than the sensitivity of the analysis which allows detection of concentrations of 3,000 pCi/liter.

Table 11. Radioactivity in milk, pCi/liter

(Local dairies)

	Aiken	Allendale	North Augusta	Waynesboro, Georgia	Major distributors [a]
Tritium [b]					
Maximum	6,000	7,000	7,000	6,000	6,000
Minimum	[c] ND	ND	ND	ND	ND
Average	ND	ND	ND	ND	ND
Strontium-90 [d]					
March	31	50	24	65	30
June	17	36	36	41	35
Cesium-137 [e]					
Maximum	160	125	105	104	120
Minimum	56	51	51	57	51
Average	95	82	72	72	86

[a] Milk produced in local dairies, but sold by major distributors.
[b] Sensitivity of analysis, 3,000 pCi/liter: MPC, 300,000 pCi/liter.
[c] Less than sensitivity of analysis.
[d] Sensitivity of analysis, 1.0 pCi/liter.
[e] Sensitivity of analysis, 25 pCi/liter; MPC 2000 pCi/liter.

Algae and fish in Savannah River

Fish (predominantly bream) and indigenous algae, primarily green (*Vaucheria*) and blue-green (*Phormidium*), were collected weekly upstream, adjacent to, and downstream from the plant. Determination of radionuclides in algae is important because algae concentrate certain radionuclides and form a part of the food chain of aquatic organisms. Data from analysis of fish and algae samples are given in table 12. Beta concentrations in algae and fish adjacent to and downstream from the plant indicate some plant contribution. Although measurably higher than similar material collected at the control station 3 miles upstream from the plant, the slight increase is of no biological significance.

Water monitoring

The plant site is drained by five streams which flow several miles through the reservation before reaching the river (figure 7). There is no industrial nor municipal use made of river water immediately below the plant site. During the January–June 1965 period, the Beaufort-Jasper Water Authority began operation of a new treatment facility to furnish sanitary water, partially supplied from the Savannah River, to most of Beaufort County, South Carolina. Water is supplied through a new canal from the river at a location about 90 miles below the Savannah River plant site. The city of Savannah also supplements its domestic well water supply with river water during periods of peak demand.

Table 12. Radioactivity in Savannah River aquatic specimens[a], pCi/g

Location	Algae (dry weight)				Fish (wet weight)						
						Bone			Flesh		
	Number of Samples	Maximum	Minimum	Average	Number of Samples	Maximum	Minimum	Average	Maximum	Minimum	Average
Control (3 miles upstream from Plant)	4	38	32	35	15	39	8	22	5	ND	3
Along Plant boundary	11	330	19	71	9	93	15	40	28	2	9
Highway 301 crossing (10 miles downstream from Plant)	18	100	22	46	21	60	13	28	22	2	8

ND indicates less than sensitivity of the analysis.
[a] Nonvolatile beta emitters; sensitivity of analysis—varied due to differing sample size.

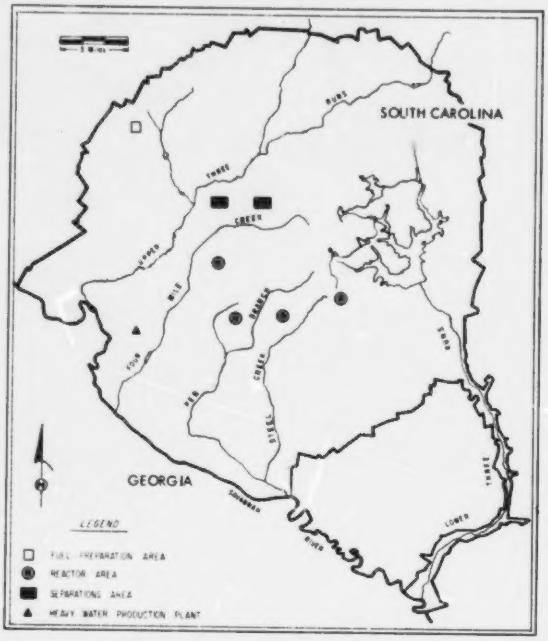

Figure 7. Savannah River Plant production areas and effluent streams

Communities near the plant get domestic water from deep wells or surface streams. Public water supplies from 14 surrounding towns are collected and analyzed monthly. Concentrations of alpha activity (1.5 pCi/liter) and beta activity (7 pCi/liter) are essentially the same as those observed before plant startup in 1951. Data from analyses of all public water samples are given in table 13.

River water, analyzed weekly, was sampled continuously at four locations (upstream, adjacent to, and as far as 10 miles downstream) as shown in figure 3. Concentrations of alpha and nonvolatile beta emitters in river water for the past year are summarized in table 14, average concentrations of specific radionuclides found in the river water during January–June 1965 are in table 15.

Radionuclides in river water upstream and downstream from the plant during the January–June 1965 period are shown in figure 8; the values represent the total quantities of radionuclides passing the two sampling points. Cesium-137, strontium-90, chromium-51, and tritium, released mainly from reactor areas, were the radionuclides of plant origin detectable in river water at the downstream location. Strontium-90 and tritium from worldwide fallout were also detected in river water upstream from the plant. Tritium (^3H), a beta emitter and the most abundant radionuclide released to the river, is produced by neutron irradiation of heavy water moderator in the reactors. Chromium-51, the second most abundant radionuclide released to the river, is produced by neutron irradiation of stable chromium (a component of the stainless steel used in reactor parts). Tritium and chromium-51 are among the least dangerous of all radionuclides because neither concentrates in body tissues. The concentration of tritium in river water averaged 3.1 percent of its MPC, and the concentration of chromium-51 was less than 0.001 percent of its MPC. Average concentrations of all radionuclides found in river water during January–June 1965 as shown in table 15, were only small fractions of the permissible concentrations.

Environmental gamma radiation levels

Monthly measurements of environmental gamma radiation were made with portable Geiger-Mueller survey instruments. January–June 1965 data in table 16 are characteristic of individual station observations during the past

Table 13. Radioactivity in public water supplies, pCi/liter

	Aiken	Allendale	Augusta	Barnwell	Bath	Blackville	Clearwater	Jackson	Langley	New Ellenton	North Augusta	Sardis	Waynesboro	Williston	Average
Alpha emitters [a]															
Maximum	5.4	[b] ND	ND	0.2	5.3	0.4	3.2	17	2.0	4.7	2.9	0.3	0.3	1.2	
Minimum	1.2	ND	ND	ND	1.8	ND	ND	2.6	1.1	1.3	ND	ND	ND	0.3	
Average	2.5	ND	ND	ND	3.7	0.3	0.7	7.4	1.6	2.4	0.6	ND	ND	0.7	1.5
Nonvolatile beta emitters [c]															
Maximum	9	6	9	5	17	6	13	40	10	13	18	4	12	7	
Minimum	ND	ND	5	ND	8	ND	ND	4	ND	7	5	ND	ND	ND	
Average	5	ND	6	ND	11	ND	7	23	7	9	9	ND	7	4	7

[a] Sensitivity of analysis—0.2 pCi/liter: MPC—10 pCi/liter.
[b] Less than sensitivity of analysis.
[c] Sensitivity of analysis—4.0 pCi/liter: MPC—3,000 pCi/liter.

Table 14. Radioactivity in Savannah River water, pCi/liter

	Control (3 miles upstream from Plant)	Plant Perimeter		Highway 301 (10 miles downstream from Plant)
		1	2	
Alpha emitters [a]				
Jan–June 1965:				
Maximum	0.7	0.9	0.7	0.5
Minimum	ND	ND	ND	ND
Average	0.3	0.2	0.2	ND
July–Dec 1964:				
Average	0.3	0.2	ND	ND
Nonvolatile beta emitters [b]				
Jan–June 1965:				
Maximum	23	34	36	24
Minimum	5	5	6	5
Average	8	13	13	10
July–Dec 1964:				
Average	10	15	14	14

ND indicates less than sensitivity of analysis.
[a] Sensitivity of analysis—0.2 pCi/liter: MPC—10 pCi/liter.
[b] Sensitivity of analysis—4.0 pCi/liter: MPC—3,000 pCi/liter.

Table 15. Average concentration of radionuclides in Savannah River water

(Concentration, pCi/liter)

Radionuclide	Sensitivity of analysis	Control (3 miles upstream from Plant)	Highway 301 (10 miles downstream from Plant)	Percent MPC at Highway 301
Tritium(^3H)	600	1,200	9,300	3.1
Ruthenium-103, 106	3.2	ND	ND	<0.10
Cerium-141, 144	2.5	ND	ND	<0.08
Cesium-134, 137	0.6	ND	1.9	<0.10
Neptunium-239	0.9	ND	ND	<0.003
Barium-Lanthanum-140	1.6	ND	ND	<0.02
Zirconium-Niobium-95	0.5	ND	ND	<0.02
Chromium-54	4.3	ND	ND	<0.001
Strontium-89	0.3	ND	ND	—
Iodine-131	0.5	ND	ND	—
Strontium-90	0.01	1.4	2.1	—
Cobalt-60	1.4	ND	ND	<0.01
Zinc-65	1.1	ND	ND	<0.01
Manganese-54	0.4	ND	ND	<0.001

ND, Less than sensitivity of analysis.

Table 16. Environmental gamma radiation

(mR/24 hours)

	Plant perimeter locations						25-mile radius locations									
	A	B	C	D	E	Average	Aiken Airport	Aiken State Park	Allendale	Barnwell	Bush Field	Langley	Sardis	Waynesboro	Williston	Average
Maximum	0.39	0.36	0.43	0.43	0.37		0.35	0.33	0.38	0.46	0.39	0.36	0.37	0.37	0.42	
Minimum	0.34	0.26	0.36	0.31	0.32		0.30	0.23	0.29	0.28	0.32	0.32	0.32	0.30	0.27	
Average	0.36	0.33	0.39	0.36	0.34	0.36	0.33	0.29	0.32	0.36	0.34	0.34	0.34	0.33	0.33	0.33

several years; the readings are not precise, but are sufficiently accurate to illustrate any significant variations above background. The differences among the values shown are within the variance anticipated due to differences in normal background and in instrument response characteristics.

Summary

The quantity of radioactive waste released by the Savannah River Plant to its environs was, for the most part, too small to be distinguished from natural background radiation, or was obscured by worldwide fallout from nuclear weapons testing during past years. Fallout from the Chinese nuclear test on May 14, 1965, was detected at SRP on air filters. Beta activity in air, which shows no relationship to plant operations, was about one-fifth of that for the same period of 1964. Radioactive materials in fresh fish continued to be far below levels considered significant from a health standpoint. The average concentration of radionuclides in river water did not exceed 3.1 percent of the maximum permissible concentrations.

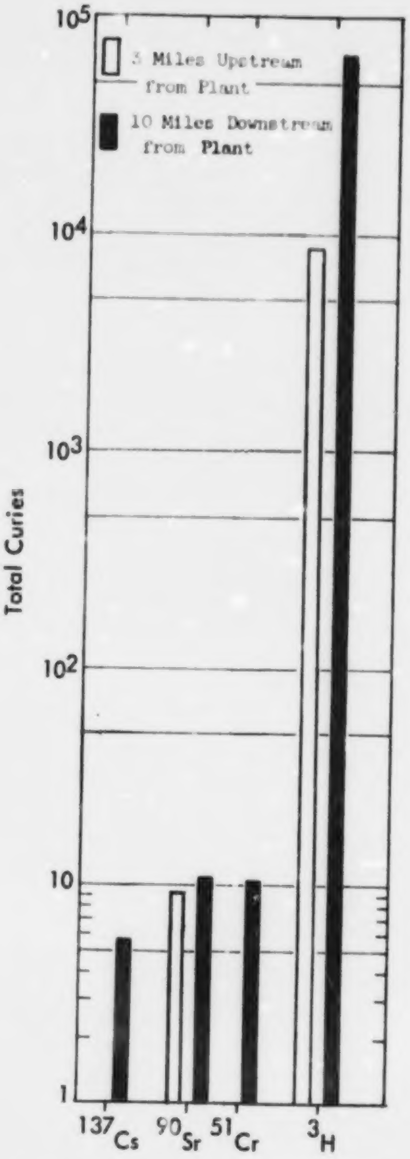

Figure 8. Radionuclides in river water during January–June 1965 (only strontium-90 and tritium were detectable upstream)

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1961	*September 1962*
Calendar Year 1962	*August 1963*
Calendar Year 1963	*August 1964*
January–June 1964	*February 1965*
July–December 1964	*August 1965*

4. Shippingport Atomic Power Station[9] January–June 1965

Duquesne Light Company
Shippingport, Pennsylvania

The Shippingport Atomic Power Station is operated for the Atomic Energy Commission by the Duquesne Light Company. The plant site is located near Shippingport Pennsylvania, along the Ohio River about 25 miles northwest of Pittsburgh.

The pressurized water reactor with core 1 ("seed and blanket" design) achieved full power on December 23, 1957, and has operated continuously except for shutdowns which were necessary for maintenance and "seed" refueling. In February 1964, the reactor was shutdown for the replacement of core 1 with core 2, the decontamination of the primary system, and the commencement of other associated reactor plant modifications. The reactor remained shut down until April 1965, at which time operations were recommenced.

An environmental monitoring program was begun 2 years before plant startup to determine the background levels of radioactivity in the environment. This program was then continued after plant startup to ensure that radioactive waste discharges from normal plant operations do not cause significant changes in these levels in the plant environment. The present program of environmental monitoring consists of measurements of radioactivity in air, fallout, and Ohio river water. Figure 9 shows the sampling locations.

Liquid radioactive waste disposal

The concentration limits for the discharge of radioactive wastes at Shippingport are based on a knowledge of the radionuclide mixture making up the waste and on the radiation protection standards of Title 10, Code of Federal Regulations, Part 20, AEC Manual, Chapter 0524; and Chapter 4, Article 433 of the Rules and Regulations, Commonwealth of Pennsylvania Department of Health. The discharge of tritium, a radioactive isotope less hazardous than fission and activation corrosion products, is controlled separately based on its own limit.

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[9] Summarized from "Environmental Radioactivity at the Shippingport Atomic Power Station for the First Half of 1965" PNRO-DEV-135.

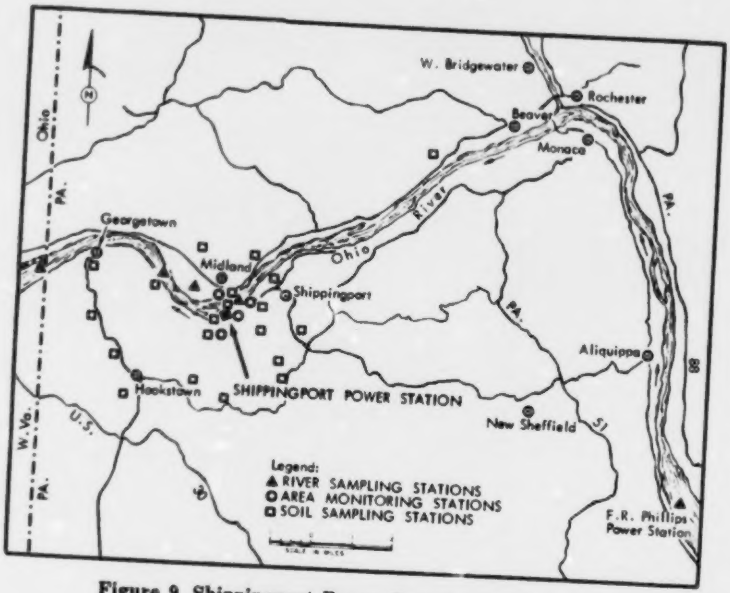

Figure 9. Shippingport Power Station sampling locations

The liquid effluent from the plant radioactive waste disposal system is carefully monitored before, during, and after release to the Ohio River to ensure that the concentration limits recommended by the above regulations are not exceeded.

The liquid radioactive wastes discharged during the first half of 1965 are summarized below. The monthly average concentrations of gross radioactivity shown in table 17 include normal background radioactivity and are calculated after total radioactive waste discharges are diluted in the condenser cooling water effluent channel. The maximum total discharge in a single day during the first half of 1965 was 1.78 millicuries.

Table 17. Total radioactive waste, exclusive of tritium, discharged into the Ohio River, January–June 1965

Period	Total discharges (millicuries)	Average discharge per day (millicuries)	Average concentration effluent channel (pCi/liter)
January	8.56	0.276	4.03
February	10.4	0.372	3.90
March	23.5	1.090	5.25
April	15.3	1.640	4.85
May	8.87	0.286	2.56
June	7.74	0.258	2.28
Total 6 months	74.4	0.652	3.85

Table 18 is a summary of the tritium that was discharged into the Ohio River, the monthly average concentration of tritium in the hold-up tanks prior to discharge, and the monthly average concentration of the waste in the effluent channel after dilution with the condenser cooling water. The maximum tritium discharged in a single day during the first half of 1965 was 20 mCi. Automatic samplers are installed at the station's river water influent and effluent to collect river water samples continuously for comparative purposes.

Since the effluent sampler was inoperative during the first 3 months of this report period, daily "grab" samples were collected. Weekly composites of the daily "grab" samples and continuous samples were analyzed for gross beta and gross alpha radioactivities in the suspended and dissolved solids. The potassium-40 radioactivity in the total solids of these samples was also measured. No significant difference was observed between the average alpha, beta, and potassium-40 radioactivity in the upstream and downstream samples. The results of these analyses are shown in table 19.

Table 18. Tritium released to Ohio River January–June 1965

Period	Total discharges (millicurie)	Average discharge per day (millicurie/day)	Average concentration in hold-up tank (pCi/liter) [a]	Average concentration in effluent channel (pCi/liter)
January	[b] —	—	<500,000	—
February	—	—	<500,000	—
March	—	—	<500,000	—
April	—	—	<500,000	—
May	—	—	<500,000	—
June	81	2.7	688,000	67.6
Total 6 months	81	0.447	520,000	10.9

[a] Minimum detectable tritium concentration = 500,000 pCi/liter.
[b] Dash indicates no tritium detected.

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Table 19. Average concentration of radioactivity in the Ohio River, January–June 1965

Type of radioactive material	Concentration, pCi/liter					
	Upstream samples			Downstream samples		
	Maximum	Minimum	Average	Maximum	Minimum	Average
Alpha						
Suspended solids	5.35	0.11	0.94	4.82	<0.03	0.90
Dissolved solids	3.41	0.01	0.84	1.86	<0.03	0.66
Total solids	8.76	0.12	1.78	6.68	<0.06	1.56
Beta						
Suspended solids	33.9	2.19	9.98	46.6	1.21	9.66
Dissolved solids	16.4	1.76	8.75	91.0	4.20	9.36
Total solids	50.3	3.95	18.77	137.6	5.41	19.02
Potassium-40						
Total solids	7.20	2.50	8.40	8.40	2.50	4.10

Atmospheric release of radioactive materials

During the first half of 1965, no radioactive gas or airborne particulate radioactivity was released from Shippingport. Station operations did not require the controlled release of any radioactive gas and the incinerator, which is normally used for burning contaminated, combustible waste, was inoperative.

Environmental monitoring

Three area monitoring stations were used to collect fallout, to detect and record levels of external beta-gamma radiation, and to detect and record levels of airborne particulate radioactivity in the power station vicinity. Stations 1, 2, and 3 are located 150 yards southeast, 150 yards west, and one-half mile north-northwest of the reactor building, respectively.

All three stations include a continuously moving paper tape air sampler with an end-window Geiger-Mueller detector and a recorder. Since the radioactivity is measured by the detector only one-half hour after its collection, naturally occurring radon and thoron daughters are also included. The data collected by the stations are checked and averaged weekly. The 6-month averages of these data from stations 1, 2, and 3 are listed in table 20.

Table 20. Average concentration of airborne particulate radioactivity, January–June 1965

Station		Concentration, pCi/m^3		
Number	Percent of time not working	Maximum	Minimum	Average
1	7.7	7.85	0	1.40
2	19.2	18.2	.0785	2.52
3	23.1	7.85	0	1.10

External beta-gamma radiation levels at each station are continuously measured and recorded by a Geiger-Mueller detector and a recorder. The data collected at each station are checked and averaged weekly. The results of these measurements, as shown in table 21, indicate that the radiation levels for stations 1 and 3 were not significantly different from the averages for these stations for previous years. The average radiation level for station 2 was higher than normal due to the handling and storage of radioactive materials in the laydown building area, which is near station 2.

Table 21. Beta-gamma background radiation levels January–June 1965

Station number	Radiation levels (mr/hr)		
	Maximum	Minimum	Average
1	0.48	0.008	0.016
2	0.60	0.020	0.140
3	0.052	0.008	0.022

The radioactive fallout at each station was collected in pots over a one-month period and analyzed for beta radioactivity. As shown in table 22, and 6-month averages for the stations did not differ significantly to indicate that any radioactivity was released by the power station.

Table 22. Beta radioactivity in fallout

Station number	Deposition rate, $nCi/m^2/month$		
	Maximum	Minimum	Average
1	78.0	10.7	23.9
2	48.6	11.4	20.8
3	43.6	10.6	19.9

Average for all stations: 21.6 $nCi/m^2/month$
Maximum: 78.0 $nCi/m^2/month$
Minimum: 10.6 $nCi/m^2/month$

Summary

During the first half of 1965, measurements of radioactivity were made in the Ohio River and the atmosphere in the vicinity of the Shippingport Atomic Power Station. The results of these measurements indicate that the radioactive material released by the power station into the Ohio River did not result in a significant change in the naturally occurring radioactivity in the environment.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1961	*April 1962*
July 1962–June 1963	*March 1964*
July–December 1963	*November 1964*
Calendar Year 1964	*August 1965*

Section V. Technical Notes

REPORTED NUCLEAR DETONATIONS, JANUARY 1966

During January 1966, three United States nuclear tests at the Nevada Test Site were announced by the Atomic Energy Commission. Low yield tests (less than 20 kilotons of TNT equivalent) were conducted underground on January 13 and 21 and a low-intermediate yield test (20 to 200 kilotons of TNT equivalent) was conducted underground on January 18, 1966.

IN MEMORIAM

Duncan C. Clark

With deep sadness we report the death on January 13, 1966, of Mr. Duncan C. Clark, who for the past six years has been Director, Division of Public Information of the United States Atomic Energy Commission. Mr. Clark served as a member of the Board of Editorial Advisors of Radiological Health Data since its inception, representing the AEC.

Mr. Clark entered Federal service in 1947 as administrative assistant to Congressman John A. Carroll of Colorado. In 1951 he joined the staff of the House Committee on Small Business as an analyst, transferring to the AEC in 1952 as a public information officer. Four years later he was named Deputy Assistant Director for Public Information, and in 1957 he was appointed Assistant Director for Public Information, a position he held until 1960, when he became Director.

During Mr. Clark's service with the AEC he drew upon his extensive background and training to clarify for reporters of many nations the many facets of the atomic energy program, including radiological safety in weapons testing, fallout, biology and medicine, radioisotopes, research, raw materials and reactor safety.

On February 28, 1958, Mr. Clark received the AEC's Sustained Superior Performance Award, which read in part:

"The vital task of keeping the public correctly and adequately informed regarding the health and safety aspects of the Commission's operations has largely been a planning and performance responsibility of Duncan Clark, Deputy Assistant Director for Public Information in the Division of Information Services. Primarily for this work, but also for other valuable services to the Commission, Mr. Clark is recommended for an award."

His colleagues and associates, who experienced his warmth, his gentleness, his understanding, and his strength of spirit, feel a keen sense of loss in his untimely passing.

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RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 7, Number 3 March 1966

In August 1959, the President directed the Secretary of Health, Education, and Welfare to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels. The Department delegated this responsibility to the Division of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Division of Radiological Health by Federal agencies, State health departments, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators. These are subject to review by a Board of Editorial Advisors with representatives from the following Federal agencies:

Department of Defense
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Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service ● Division of Radiological Health

Reports

VARIABILITY OF FLUID MILK CONSUMPTION AND ITS RELATIONSHIP TO RADIONUCLIDE INTAKE[1]

J. C. Thompson, Jr.[2]

SYNOPSIS—Using Federal milk marketing order statistics and population estimates for market areas, average monthly fluid milk consumption estimates were derived for cities located in areas covered by the Public Health Service Pasteurized Milk Network. The average per capita milk consumption for 67 cities in July 1962 was found to be 0.302 liters per day, which compared well with the Bureau of the Census estimate of 0.297 liters per day for the same month. Establishment of a comparative milk consumption—radionuclide level network is described for the 38 cities which participate in both collection of the milk order statistics and the PHS milk monitoring system. This method is useful for determining regional and temporal variations in average milk consumption. Widespread geographic variations in radionuclide intakes are apparent from a summary of data for these cities, ranging to as high as sixfold for strontium-90 and fifteenfold for cesium-137 between stations. The estimates indicate that the average intake of strontium-90 and cesium-137 are approximately 70 percent less than estimates based on an assumed milk consumption of 1 liter per day. It is emphasized, however, that the averages include portions of the population whose milk intake is considerably greater than the average. These represent the critical elements in public health planning if large releases of radioactivity should occur.

The worldwide levels of environmental radioactivity observed following atmospheric nuclear tests conducted by the United States and U.S.S.R. in 1961–1962 emphasized the importance of improving our methods of estimating radionuclide intake. This was particularly true for the actions taken by some States in attempting to reduce iodine–131 intake levels. These actions were based on iodine–131 intake estimates derived from measured iodine–131 levels in milk and arbitrary milk consumption data. None of the actions taken were recommended by Federal authorities. However, the fact that they were initiated points out the necessity for establishing a better understanding of the interrelationships that exist between milk consumption, iodine–131 intake, and thyroid uptake. These relationships are very important in determining any hazard from fallout iodine–131 radioactivity. They can also assist in evaluating the hazards from other major radionuclides found in milk, since it forms an important part of the diet.

The urgency of the measures taken by individual States was primarily related to the inherent characteristics of iodine–131; it is produced in large amounts during a nuclear detonation, efficiently secreted into edible food products, and is concentrated in a small gland (thyroid). Because of its short radioactive half-life (8 days), iodine–131 has special importance in food products that spend short-time periods in marketing channels. Thus, fresh whole milk was the most important food product of concern, because most other foods normally spend sufficient time in marketing channels to significantly decrease or eliminate iodine–131 levels by radioactive decay. Homegrown or locally produced vegetables might enter into consideration for certain population categories, but the quantities of iodine–131

---

[1] This work was partially supported by the U.S. Atomic Energy Commission.

[2] Dr. Thompson is assistant professor of the Department of Physical Biology, New York State Veterinary College (a contract college of the State University), Cornell University, Ithaca, New York.

available from these sources would be small (*1*). Standard home preparation practices (washing, peeling, etc.) would generally minimize the intake from these sources.

In order to properly assess the intake of iodine–131 or any radionuclide from milk, it is necessary to have accurate data on milk consumption. In the past, the practice has been to base estimates on an assumed milk consumption rate of 1 liter per person per day. However, this practice can lead to considerable error among various regions and locations and may contribute to public uncertainty and alarm during nuclear testing periods such as those of 1961 and 1962. If radionuclide intake levels are used as criteria for determining whether countermeasures are deemed advisable, then accurate consumption data are essential for this determination. Accurate milk consumption data can also assist in determining total radionuclide intake, since there is a correlation between total diet intake and the contribution from milk.

It is possible to obtain considerable data on fluid milk, since it is one of the few products that are extensively controlled throughout the United States, both at Federal and State levels. These controls range from sanitary codes to pricing regulations at producer, distributor, and retail levels. Such controls make it possible to obtain more meaningful and accurate data than are available for most other foods. Most of the data that are relevant for determining milk consumption are derived from Federal milk marketing order statistics which report sales of various milk products by specific marketing areas (*2*). Jurisdiction over milk sales on a regional basis is under Federal supervision and control in the 80 markets having Federal milk marketing orders. These orders are supervised by a market administrator appointed by the Secretary of Agriculture. Milk handlers are regulated under the provisions of such an order in the following manner:

(a) They must pay the minimum farm price as established by the Market Administrator's Office.

(b) They must make accurate weights and tests.

(c) They must properly account for the way in which the milk is used (quantities of milk received and sales in each product category).

These regulations are supplemented by the various Federal and State sanitary codes which often include reports on sales and disposition of fluid milk products.

Federal milk marketing order statistics report total monthly fluid milk sales in the area designated by the marketing order. Sales reports are filed for each Federal order area on a weight basis for sales within the area and verify the use which handlers have made of milk purchases from producers (sales by product category, type of container, etc.). All out-of-market sales are deleted from reported figures. Thus, except for losses in the store or home (spoiling, spilling, etc.) the data are indicative of the milk consumed in each market area.

Population estimates for each market area are updated annually by using information derived from census data and trends, population projections and estimates from State planning and development boards, business research, and other statistical services. These estimates consider only the persons living within the established boundaries of each Federal milk marketing order area.

Since 1962 the quantity of milk handled by all Federal marketing orders has represented about half of the milk delivered to all plants and dealers in the United States. However, within each individual market order area the data account for *all* of the sales made in the area. These sales data are subdivided according to the uses or products manufactured as required in a classified milk pricing program. Fluid milk sales data can then be extracted and related to the population data for each area to obtain the desired consumption estimates. Table 1 shows the average monthly fluid milk consumption in 1964 for the cities from the Federal milk marketing order network which are also located in areas covered by the Public Health Service Pasteurized Milk Network.

These data can be compared with fluid milk consumption estimates derived from the Bureau of the Census — Public Health Service study conducted in July 1962 (*4, 5*). The average per capita milk consumption from this study was 0.297 liters per day (weighted aver-

Table 1. Average monthly per capita fluid milk consumption during 1964 in 38 major U.S. milksheds (*3*)

Major city in milkshed	Liters per month	Major city in milkshed	Liters per month
Albuquerque, N.M	7.9	Memphis, Tenn	7.7
Austin, Tex	8.3	Milwaukee, Wis	9.2
Baltimore, Md	7.6	Minneapolis, Minn	10.8
Boston, Mass	11.5	New Orleans, La	7.6
Buffalo, N.Y	9.8	New York, N.Y	11.3
Charlotte, N.C	6.0	Oklahoma City, Okla	10.0
Chattanooga, Tenn	9.7	Omaha, Nebr	9.0
Chicago, Ill	9.7	Philadelphia, Pa	9.1
Cincinnati, Ohio	8.8	Phoenix, Ariz	8.3
Cleveland, Ohio	10.5	Providence, R.I	11.8
Dallas, Tex	8.6	Rapid City, S.D	9.8
Denver, Colo	8.3	St. Louis, Mo	8.0
Des Moines, Iowa	9.3	Salt Lake City, Utah	7.8
Detroit, Mich	10.8	San Francisco, Calif	9.2
Hartford, Conn	11.0	Seattle, Wash	8.4
Indianapolis, Ind	9.5	Spokane, Wash	6.3
Kansas City, Mo	8.9	Washington, D.C	9.0
Little Rock, Ark	6.4	Wichita, Kans	8.6
Louisville, Ky	8.7	Wilmington, Del	9.1
		Average	9.0

age using all age groups and both sexes) for the month of July 1962. This compares with an average of 0.302 liters/day from the 67 Federal milk market order stations operating during the same month. The close agreement of results indicates the similarity between the estimating procedures. Since the Federal milk marketing program offers the advantage of more recent information, its use would be advantageous in any appraisal of radionuclide intake. In addition, it would permit an evaluation of regional as well as individual market variations on an annual or seasonal basis. Some of these differences are shown in table 2 for the markets which are included in the Public Health Service Pasteurized Milk Network. The pattern of consumption is generally consistent from year to year with small changes in seasonal or annual totals.

Table 2. Fluid milk consumption by geographic regions of the United States; 38 markets located within PHS Pasteurized Milk Network, 1964

Month	Milk consumption, liters/capita per month				
	Northeast	North Central	South	West	Average
January	11.1	10.0	8.5	8.5	9.4
February	11.0	10.0	8.5	8.5	9.4
March	10.8	9.6	8.2	8.1	9.1
April	10.9	9.7	8.3	8.3	9.2
May	10.6	9.1	7.9	7.9	8.7
June	10.5	8.7	7.6	7.5	8.4
July	10.2	8.6	7.6	7.3	8.3
August	10.2	8.7	7.6	7.4	8.3
September	11.0	9.8	8.7	8.3	9.3
October	11.3	10.2	9.0	8.6	9.7
November	10.8	9.6	8.5	8.1	9.1
December	10.8	9.5	8.2	8.0	9.0
Average	10.8	9.4	8.2	8.0	9.0

Seasonal changes generally involve a summer decline which can be related to such factors as temperature and the number of children out of school. Normal consumption levels are resumed when schools reopen and, except for a small holiday decline, are maintained until the following summer.

Variation in milk consumption by age and sex is another important consideration and was also cited in the Bureau of the Census — Public Health Service study. Some of the more pertinent points were the higher consumption rate for male persons (37 percent greater than female), the similarity of consumption patterns up to the late teens, and the lack of any group having average daily consumption levels over 0.6 liters. These data are in agreement with consumption information from a similar study conducted in Canada during the spring of 1963 (*6*). However, the Canadian study reported a very low daily intake estimate for babies younger than 6 months of age (average daily consumption was 0.47 liters). Other points, such as much higher consumption for rural farm areas, were also in agreement with previous U.S. data (*7*).

By incorporating all of the available data for an individual market it becomes possible to derive estimates of radionuclide intake from milk for different components of the population. The Boston area is used to illustrate this approach:

The July 1962 average fluid milk consumption for the Boston area (Federal milk market statistics) was 0.353 liters per person per day. This compares with the average of 0.297 liters per day for the Bureau of the Census — Public Health Service study. Therefore, Boston consumption was 18.8 percent higher than the average of 38 milksheds and this figure could serve as a weighting factor for determining differences in consumption due to age and sex (table 3).

This procedure would then give a good estimate of the milk consumed by the population of the Boston area. It could then be used with radionuclide concentration data from this milkshed to establish intake by each segment of the population. Prediction studies and hazard estimates could then be made and correlated to observed levels whenever determined by bone analyses, whole body counts, or thyroid monitoring.

Table 3. Example of adjusted milk consumption by age group for specific area (Boston, Massachusetts), July 1962

Age	Daily per capita milk consumption (liters/day)			
	Census—PHS study		Adjusted consumption [a]	
	Male	Female	Male	Female
Under 1	.527	.479	.626	.569
1–4	.530	.503	.630	.598
5–9	.479	.447	.569	.531
10–14	.510	.382	.606	.454
15–19	.510	.293	.606	.348
20–24	.352	.213	.418	.253
25–29	.293	.192	.348	.228
30–34	.263	.166	.312	.197
35–44	.243	.160	.289	.190
45–54	.228	.154	.271	.183
55–64	.240	.169	.285	.201
65+	.246	.192	.292	.228
All ages	.346	.251	.411	.298

[a] Using weighting factor of 1.188

The assumption of a population composition similar to the U.S. distribution insofar as numbers of male and female persons in respective age groups would be required in this analysis. This is a reasonable assumption for the larger market areas which are in the Federal milk market network. Using this approach would permit an appraisal of monthly, geographic, age, and sex related variations in fluid milk consumption. More recently, monthly or annual estimates could be calculated in the same manner.

Applications of this method are particularly suited to estimates of radionuclide intake from milk. Information on the variables influencing milk consumption is more readily available than on most other foods because of the reporting systems and controls that are employed. This is also true for radionuclide data since the sampling of milk for radionuclide determination is a regular feature of the monitoring networks. Thus, it is possible to establish a comparative milk consumption-radionuclide level network for the 38 cities that collect Federal (or State) milk order statistics and are a part of the Public Health Service milk monitoring system (*8*). Results from this compilation permit a better evaluation of the radionuclide intake from milk throughout the country. When these data are summarized, widespread geographic variations become apparent (table 4).

In general, the ranking by area follows the pattern indicated (Northeast, North Central, South, and West, in descending order). Individual variations between stations for a given year and area extend from two- to sixfold for strontium–90 and from two- to fifteenfold for cesium–137. With an awareness of this variation in one food item, it is easy to see how single dietary estimates can be extremely inaccurate.

Wide variations may also occur in estimating the milk component of total diets. Previous total diet studies (excluding infant diets) have shown the contribution of milk to total radionuclide intake to vary from 70 to 100 percent for iodine–131 (*1*), 10 to 90 percent for strontium–90, and 10 to 90 percent for cesium–137 (*9, 10*). The presence of such widespread variations would indicate that an analysis of each market and its component population is necessary so that individual factors can be considered.

The use of monthly milk consumption data, as developed here, in conjunction with radionuclide data will provide more accurate regional and market estimates of radionuclide intake from milk. This is shown in tables 5 and 6 where strontium–90 and cesium–137 intake

Table 4. Comparison of strontium-90 and cesium-137 intake from milk by geographic area, 38 major milk markets of the United States, 1961–1964

Area	pCi strontium-90/capita • year				pCi cesium-137/capita • year			
	1961	1962	1963	1964	1961	1962	1963	1964
Northeast	1,220	1,662	3,283	3,006	1,966	6,989	20,894	19,208
North Central	1,058	1,433	2,676	2,661	1,037	4,285	11,347	11,269
South	917	1,757	2,623	2,739	800	4,179	9,744	8,509
West	771	902	1,654	1,663	1,021	3,831	9,462	8,813
38-market average	986	1,500	2,626	2,556	1,104	4,622	12,413	11,201

Table 5. Estimated annual average per capita strontium-90 intake from milk in 38 market areas of the United States in 1964; comparison of intake levels based on assumed and actual milk consumption rates

Market area	Annual intake (picocuries)		Market area	Annual intake (picocuries)	
	Assumed [a]	Actual [b]		Assumed [a]	Actual [b]
Albuquerque, N.M	4,015	1,060	Memphis, Tenn	11,680	2,910
Austin, Tex	3,285	845	Milwaukee, Wis	6,205	1,885
Baltimore, Md	8,030	1,975	Minneapolis, Minn	11,315	3,995
Boston, Mass	11,315	4,235	New Orleans, La	18,250	4,595
Buffalo, N.Y	7,300	2,305	New York, N.Y	9,125	3,365
Charlotte, N.C	13,140	2,575	Oklahoma City, Okla	8,030	2,670
Chattanooga, Tenn	14,600	4,610	Omaha, Nebr	9,125	2,605
Chicago, Ill	6,935	2,170	Philadelphia, Pa	7,300	2,250
Cincinnati, Ohio	8,030	2,310	Phoenix, Ariz	1,460	450
Cleveland, Ohio	7,665	2,615	Providence, R.I	8,395	3,270
Dallas, Tex	6,935	1,955	Rapid City, S. Dak	14,235	4,580
Denver, Colo	6,935	1,935	St. Louis, Mo	8,030	2,135
Des Moines, Iowa	9,125	2,725	Salt Lake City, Utah	9,125	2,400
Detroit, Mich	6,570	2,320	San Francisco, Calif	3,650	1,080
Hartford, Conn	7,300	2,615	Seattle, Wash	9,490	2,635
Indianapolis, Ind	7,300	2,255	Spokane, Wash	10,220	2,075
Kansas City, Mo	9,855	2,825	Washington, D.C	6,935	2,045
Little Rock, Ark	15,695	3,255	Wichita, Kans	7,665	2,170
Louisville, Ky	10,950	3,070	Wilmington, Del	8,030	2,355
			Average	8,770	2,500

[a] Strontium-90 intake from assumed consumption rate is based on 1 liter/day.
[b] Strontium-90 intake from actual consumption rate is based on data from Federal milk marketing statistics.

Table 6. Estimated annual average per capita cesium-137 intake from milk in 38 market areas of the United States in 1964; comparison of intake levels based on assumed and actual milk consumption rates

Market area	Annual intake		Market area	Annual intake	
	Assumed [a]	Actual [b]		Assumed [a]	Actual [b]
Albuquerque, N.M	19,345	5,095	Memphis, Tenn	24,820	6,220
Austin, Tex	13,870	3,730	Milwaukee, Wis	43,800	13,260
Baltimore, Md	32,850	8,115	Minneapolis, Minn	49,275	17,560
Boston, Mass	74,095	28,160	New Orleans, La	49,275	12,295
Buffalo, N.Y	47,815	15,485	New York, N.Y	53,290	19,925
Charlotte, N.C	38,325	6,985	Oklahoma City, Okla	23,725	7,865
Chattanooga, Tenn	40,515	12,820	Omaha, Nebr	31,755	8,780
Chicago, Ill	39,785	12,700	Philadelphia, Pa	40,150	12,415
Cincinnati, Ohio	31,390	9,185	Phoenix, Ariz	9,125	2,480
Cleveland, Ohio	39,055	13,655	Providence, R.I	54,750	21,140
Dallas, Tex	21,170	5,895	Rapid City, S. Dak	51,830	16,745
Denver, Colo	32,120	8,690	St. Louis, Mo	27,010	7,175
Des Moines, Iowa	30,295	9,260	Salt Lake City, Utah	60,225	15,400
Detroit, Mich	38,325	13,555	San Francisco, Calif	17,520	5,240
Hartford, Conn	49,275	18,125	Seattle, Wash	52,560	14,795
Indianapolis, Ind	33,215	10,375	Spokane, Wash	48,180	9,940
Kansas City, Mo	26,695	7,870	Washington, D.C	28,835	8,515
Little Rock, Ark	42,705	8,765	Wichita, Kans	22,995	6,470
Louisville, Ky	29,565	8,560	Wilmington, Del	41,245	12,360
			Average	37,110	11,200

[a] Cesium-137 intake from assumed consumption rate is based on 1 liter/day.
[b] Cesium-137 intake from actual consumption rate is based on data from Federal milk marketing statistics.

from milk are compared under an assumed consumption rate of 1 liter per day with actual consumption data from Federal milk market statistics. Estimates of strontium-90 and cesium-137 intake from milk derived from Federal milk market statistics are approximately 70 percent less than estimates based on an assumed consumption rate of 1 liter per day.

It may be noted that these estimates are consistent with average consumption data both from the Bureau of the Census—Public Health Service study and those of the Federal milk marketing program. The averages, however, include about 10 percent of the population who consume 1 liter or more of milk daily, as well as a substantial proportion (about one-third) who consume little or no milk (*4, 5*). Consequently, an assumed consumption rate of 1 liter a day would constitute a conservative basis for consideration of any emergency action if large releases of radioactivity should occur. Information on radionuclide levels and regional consumption using available Federal milk marketing data would help to locate the most vulnerable geographic area and, through adjustments similar to those shown in table 3, would provide an indication of intake by various age groups within individual markets.

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CESIUM-137 IN FOOD—A SUMMARY OF RESULTS ON SELECTED FOODS IN THE UNITED STATES, JULY 1962 TO OCTOBER 1963

Lloyd R. Setter, Donald Smith, and Mozart Spector[1]

SYNOPSIS—Cesium-137 content and cesium-137 to potassium ratios are summarized for nine staple foods sampled during a survey conducted for six consecutive quarters from July 1962 through October 1963. Insofar as possible, the results have been grouped by the six broad geographical production regions that were previously used for comparing strontium-90 data for the same samples.

The general trend of the cesium-137 to potassium ratios was similar to the strontium-90 to calcium ratios previously reported, being generally higher in fruits and vegetables than in milk; however, the lowest ratios were found in lettuce, cabbages, potatoes, and eggs. It was noted that the region-to-region variations of cesium-137 concentrations were greater than those of strontium-90 for whole milk, evaporated milk, bread, apples, and oranges.

As part of its program to assess radiation exposure from foods, the Division of Radiological Health has determined the cesium-137 content of selected staple foods sampled during six consecutive quarters beginning in July 1962. For the reader's information it is pointed out that food consumption data were obtained by separate concurrent household surveys conducted from July 1962 to April 1963. A part of the food consumption data was previously reported (*1, 2*). The sampling and analytical procedures used to develop cesium-137 data for this report have been described in a previous summary of strontium-90 results for the same samples (*3*).

Table 1 summarizes the number of cesium-137 analyses of each kind of food conducted during each survey quarter. Detailed analytical results for cesium-137 concentrations, and cesium-137 to potassium ratios are summarized in the appendix by respective maximum, minimum, median, arithmetic mean, and U.S. average values for all foods, regions (see figure 1), and survey periods.

Table 1. Number of food samples analyzed for cesium-137 collected in conterminous United States, by survey quarters

Food samples	1962		1963				Total
	July	Oct	Jan	Apr	July	Oct	
Milk: whole [a]	91	84	93	117	117	110	612
evaporated	NS	48	35	34	25	28	170
Bread: white	61	50	44	45	55	53	308
Fruit: apples	13	47	29	25	NS	NS	114
oranges	NS	NS	NS	NS	14	11	25
Meat: beef	13	14	13	12	NS	NS	52
pork	NS	NS	NS	NS	21	25	46
Vegetables: lettuce	40	26	24	15	NS	NS	105
cabbage	NS	NS	NS	NS	24	32	56
Eggs	NS	NS	27	27	26	25	105
Potatoes	NS	NS	18	27	31	33	109
Oleomargarine	NS	NS	29	27	NS	NS	56
Cereal	NS	NS	NS	NS	34	33	67
Total	218	269	312	329	347	350	
Grand total [b]							1,825

[a] Regular pasteurized milk network samples of the Division of Radiological Health collected in the Bureau of Census regions during the household survey periods.
[b] Excluding coffee
NS, no samples collected

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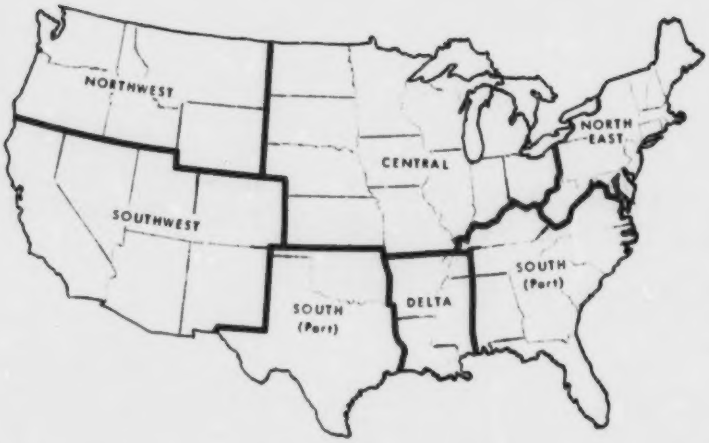

Figure 1. Regional areas for 1962–1963 food survey—modified regions used by Morgan (*4*)

Interlaboratory comparison of analyses

Analytical control studies performed by the three participating Division laboratories indicated agreement within plus or minus 25 percent of the mean cesium–137 to potassium ratio for 18 of 21 diet cross-check samples. Cross-check milk sample results showed agreement within plus or minus 5 percent of mean cesium–137 concentrations and plus or minus 8 percent of mean potassium concentrations.

Average cesium–137 contents of U.S. foods

Among the survey results for the conterminous United States (figure 2), the cesium–137 concentrations and cesium–137 to potassium ratios for evaporated milk, whole milk, meat, and bread generally increased throughout the study with a sharp rise appearing between the fourth and fifth quarters. It is of interest to note that similar patterns were found in the strontium–90 and strontium–90 to calcium ratios for these foods, as previously reported (*3*).

Foods having the highest cesium–137 concentration and cesium–137 to potassium ratio in this survey were evaporated milk, whole milk, cereals, and bread; foods having the lowest concentration of cesium–137 were oleomargarine, eggs, lettuce, potatoes, and apples. Eggs, potatoes, and leaf vegetables had particularly low cesium–137 to potassium ratios.

In comparing cesium–137 content with previously reported strontium–90 content of foods (*3*), it is noted that most foods having low concentrations of cesium–137 also have low concentrations of strontium–90, and vice versa. Notable exceptions include meat, which was low in strontium–90 and high in cesium–137; lettuce and cabbage had comparatively high strontium–90 contents but were low in cesium–137.

Regional variation of cesium–137 by sampling periods

Except for somewhat reduced cesium–137 concentrations in foods of the Southwest, the cesium–137 concentrations in foods of the other five regions had a common mean value each quarter. Consequently, a detailed regional examination of the results for each sampling period appeared of limited value.

Regional variation of cesium–137 by harvest years

The average of median and mean values for each sampling has been used for harvest year

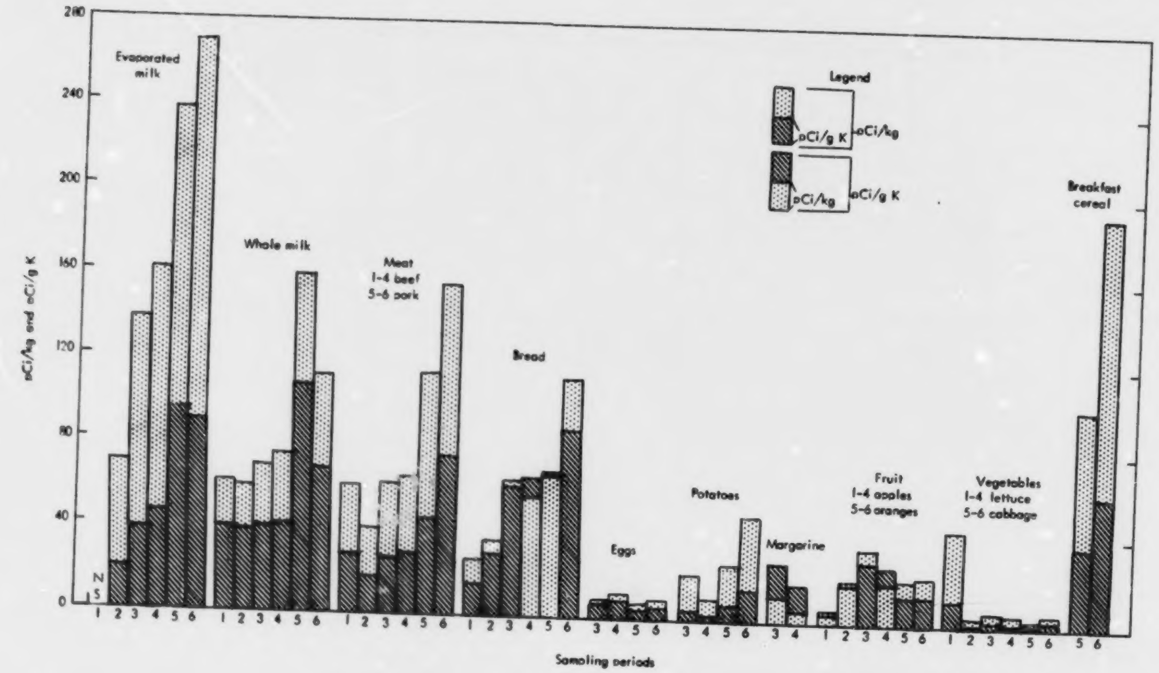

Figure 2. U.S. average cesium-137 in food by sampling period

comparisons of cesium-137 in whole milk (pCi/liter) and other foods (pCi/kg). The four sampling periods from July 1962 through April 1963 define harvest year 1962, and the sampling periods of July and October 1963 have been considered representative of harvest year 1963. These results are presented in tables 2 and 3 and plotted in figure 3. For comparison with whole milk values, the evaporated milk was computed as reconstituted evaporated milk

Table 2. Cesium-137 in foods by harvest year and region (concentrations in pCi/kg) [a]

Food item	United States	South-west	North-west	Central	North-east	South	Delta
Harvest year 1962							
Evaporated milk	113.0	[b] 90.0	[b] 119.0	[b] 122.0	[b] 116.0	[b] 138.0	[c] 92.0
Reconstituted evaporated milk [d]	60.0	45.3	60.2	61.5	58.8	69.7	46.4
Whole milk [e]	61.5	39.4	73.4	57.2	73.8	58.4	66.9
Meat, beef	47.5	52.0	(f)	43.0	(f)	[b] 47.8	(f)
Bread, white	43.6	40.0	[c] 33.0	42.0	[c] 62.0	37.0	(f)
Apples	14.7	4.0	12.7	15.5	25.7	16.0	(f)
Lettuce	12.0	25.0	[c] 26.0	5.0	[b] 2.0	2.5	(f)
Potatoes	14.0	[c] 14.5	[c] 11.2	[c] 5.7	[c] 14.0	35.0	(f)
Eggs	8.0	3.0	(f)	9.5	13.2	5.7	(f)
Oleomargarine	6.5	[g] 1.0	(f)	[g] 5.2	[g] 10.7	[g] 9.0	(f)
Harvest year 1963							
Evaporated milk	298.0	157.0	[g] 331.0	[g] 306.0	381.0	303.0	(f)
Reconstituted evaporated milk [d]	157.0	83.0	174.0	161.0	200.0	159.0	(f)
Whole milk [e]	131.0	73.0	181.0	112.0	176.0	122.0	121.0
Meat, pork	118.0	97.0	(f)	133.0	(f)	128.0	(f)
Bread, white	83.0	62.0	(f)	89.0	81.0	101.0	(f)
Oranges	(f)	7.2	(f)	(f)	(f)	74.0	(f)
Cabbage	2.8	0.5	[g] 0.0	0.7	2.5	[g] 7.2	(f)
Potatoes	36.6	[g] 11.2	[g] 36.0	43.5	35.0	[g] 57.0	(f)
Eggs	5.5	6.0	(f)	3.5	0.0	[g] 12.7	(f)
Cereal:	146.0						
Corn flakes	5.0						

[a] Sampled for four quarters in 1962 and for 2 quarters in 1963 except as follows:
[b] Sampled for three quarters
[c] Sampled for two quarters
[d] Reconstituted to calcium content in 1 liter of whole milk
[e] pCi/liter
[f] Insufficient data for calculation
[g] Sampled for one quarter

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Table 3. Cesium-137/potassium ratio in foods by harvest year and region (pCi ^{137}Cs/g K) [a]

Food item	United States	Southwest	Northwest	Central	Northeast	South	Delta
Harvest year 1962							
Evaporated milk	40.4	[b] 23.4	[b] 45.2	[b] 37.4	[b] 46.7	[b] 42.0	[c] 48.0
Whole milk	37.8	27.0	38.0	36.0	43.0	[b] 42.0	40.0
Bread, white	43.0	47.0	[c] 50.0	42.0	[c] 56.0	30.0	(d)
Meat, beef	19.7	23.6	(d)	19.1	(d)	22.2	(d)
Apples	11.8	3.4	6.0	13.0	23.0	13.0	(d)
Lettuce	4.0	3.1	[c] 13.5	1.7	[b] 1.2	0.5	(d)
Potatoes	2.5	[c] 3.7	[c] 2.5	[c] 1.2	[c] 3.5	[c] 8.0	(d)
Eggs	6.2	2.0	(d)	8.7	9.2	4.0	(d)
Oleomargarine	18.2	[c] 3.2	(d)	[c] 12.7	[c] 32.0	[c] 25.0	(d)
Harvest year 1963							
Evaporated milk	90.0	46.0	[c] 109.0	[c] 88.0	112.0	96.0	(d)
Whole milk	85.0	51.0	120.0	70.0	113.0	81.0	82.0
Bread, white	89.0	83.0	(d)	98.0	93.0	81.0	(d)
Meat, pork	49.0	48.0	(d)	52.0	(d)	47.0	(d)
Oranges	25.0	4.0	(d)	(d)	(d)	46.0	(d)
Cabbage	1.3	0.2	[c] 0.0	0.2	2.0	[c] 7.0	(d)
Potatoes	8.7	[c] 3.2	[c] 9.5	11.0	7.7	[c] 12.0	(d)
Eggs	4.0	4.2	(d)	2.5	0.0	9.2	(d)
Cereal:	48.0						
Corn flakes	5.2						

[a] Harvest year 1962 includes samples collected July 1962 to April 15, 1963 (four quarters) and harvest year 1963 includes sampling in July and October 1963 (two quarters) except as follows:
[b] Sampled for three quarters
[c] Sampled for two quarters
[d] Insufficient data for calculation
[e] Sampled for one quarter

on the basis of the equivalent calcium content (1.2 grams) of 1 liter of whole milk. It is evident that the whole milk usually had less cesium-137 than the reconstituted evaporated milk.

Reconstituted evaporated milk and whole milk had similar cesium-137 contents and cesium-137 to potassium ratios for each of the regions in harvest year 1962. The values for the Southwest averaged about 35 percent lower than those of the other regions. This pattern was repeated in harvest year 1963 with certain exceptions. Although the Southwest samples again had the least amount of cesium-137 in milk, the concentrations were about twice as high in 1963 as in 1962 and varied more in the other regions.

Foods having the highest cesium-137 concentrations (ranging from 33 to 74 pCi/kg) in harvest year 1962 were reconstituted evaporated milk, whole milk, bread, and meat. The same foods again had the highest cesium-137 concentrations in harvest year 1963, but at substantially higher levels (ranging from 60 to 200 pCi/kg). Potatoes also showed marked increases in cesium-137 content in harvest year 1963. The cesium-137 content of cabbage was found to be low in 1963, and in most regions was lower than that of lettuce sampled in 1962.

In general, there appears to be no clear pattern of regional differences in cesium-137 content in foods by harvest years except for the relatively low levels in milk from the Southwest. The general trend of the cesium-137 to potassium ratios appears similar to that of strontium-90 to calcium previously reported (*3*); however, variations from region to region are greater for whole milk, evaporated milk, bread, apples, and oranges.

Harvest year ratio comparisons

Six of the foods sampled in 1962 were also sampled in 1963. Meat is included with these even though beef was sampled in 1962 and pork was sampled in 1963. The magnitude of the cesium-137 to potassium ratios for these foods in 1963 relative to the 1962 ratios are shown in table 4.

Considering first whole milk and evaporated milk, it may be noted that the 1963/1962 ratios vary from 1.89 in the Southwest to 3.16 in the Northwest with a median value of 2.28. If to these two foods are added the values for bread, meat, potatoes, and eggs, the ranges are wider: (0.2 for meat in the South to 9.2 for potatoes in the Central region), although the median (at 2.06) is relatively unchanged. In the previous report it may be observed that the ratio of calcium for the 2 years 1963/1962 was 1.8.

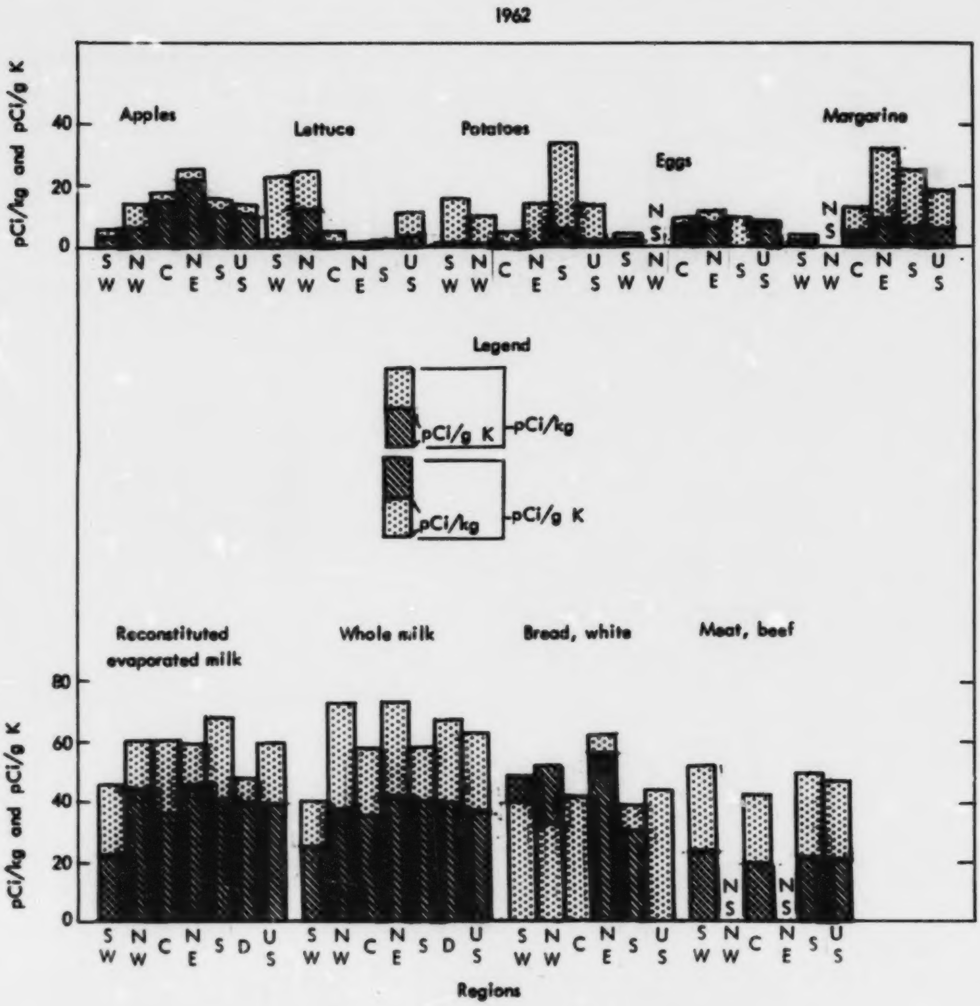

Figure 3. Cesium–137 in foods during harvest year 1962

A similar compilation of the cesium–137 results for the 2 years gives a value of 2.24 for milk and an average value of 2.25 for the five foods (whole and evaporated milk, bread, eggs, and potatoes) or an apparent greater relative increase of 25 percent for cesium–137 over that observed for strontium–90.

The ratio of cesium–137 to strontium–90 as an indicator

Cesium–137 determinations are usually nondestructive examinations of samples by multichannel gamma spectrometry, whereas radiochemical techniques which are time-consuming and relatively expensive are necessary for determining strontium–90. The use of cesium–137 concentrations to estimate the strontium–90 content is therefore of considerable practical interest. For a general treatment of the subject, ratios of the cesium–137 concentration in table 2 as compared to the strontium–90 concentrations previously reported (*3*) were derived for the six foods common to both harvest years. The results in table 5 show that

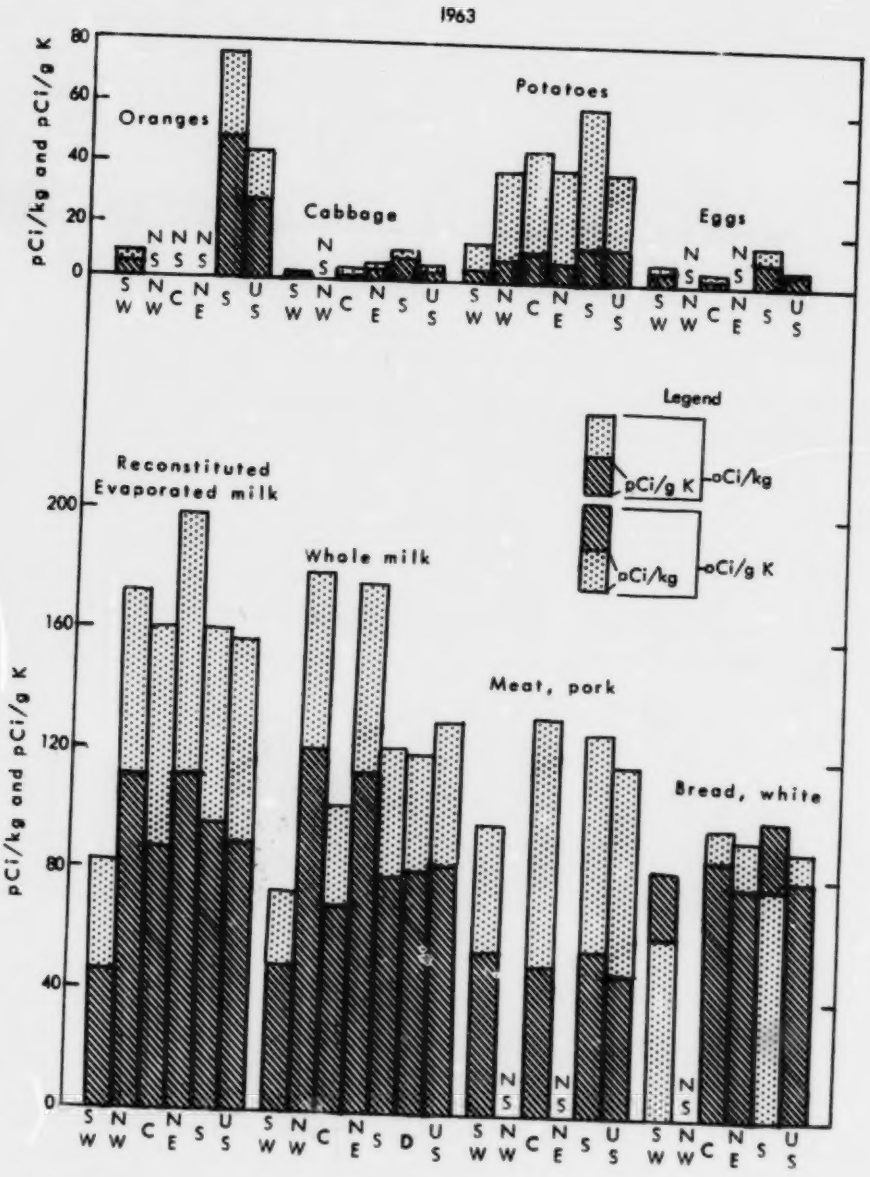

Figure 3—continued. Cesium-137 in foods during harvest year 1963

the ratios of cesium-137 to strontium-90 vary widely between regions for most of the foods, ranging from 11.7 for 1962 potatoes to 0.4 for 1963 eggs. The smallest variation in cesium-137 to strontium-90 ratio for any food was observed in bread, ranging from 3.1 to 4.6 over both harvest years and all regions.

Nevertheless, the average ratio for the five foods in table 5 is about 4, or a very rough approximation of the strontium-90 would be one-fourth the cesium-137 concentration.

Summary and conclusions

Cesium-137 concentrations and cesium-137 to potassium ratios for foods sampled during

Table 4. Cesium-137 in 1963 harvest food as compared to 1962 harvest food [a]

Food	$^{137}Cs/K$ for 1963 to $^{137}Cs/K$ for 1962					
	Southwest	Northwest	Central	Northeast	South	Delta
Evaporated milk	1.97	2.41	2.35	2.40	2.28	(b)
Whole milk	1.89	3.16	1.94	2.63	1.93	2.05
Bread	1.77	(b)	2.33	1.67	2.70	(b)
Meat	2.06	(b)	2.72	(b)	0.20	(b)
Potatoes	0.87	3.80	9.20	2.20	1.50	(b)
Eggs	2.10	(b)	0.29	0.0	1.84	(b)

[a] Foods including meat which were not common in both harvest years and their respective $^{137}Cs/K$ ratios for the 2 years were as follows: 1963 lean pork/1962 beef—0.20 to 2.72 (see above), 1963 cabbage/1962 lettuce—0 to 14 with an average of 0.33, and 1963 oranges/1962 apples—2.12 to 3.55 with an average of 2.83.

[b] Insufficient data for ratio calculation

Table 5. Ranges of regional ratios and U.S. average of cesium-137 to strontium-90 concentrations [a]

Food	Harvest year	Range, pCi ^{137}Cs/pCi ^{90}Sr				U.S. average
		Maximum	Region	Minimum	Region	
Whole milk	1962	6.0	Southwest	2.2	Delta	3.8
	1963	5.8	Southwest	3.4	Delta	4.7
Evaporated milk	1962	7.1	Northwest	2.1	Delta	4.0
	1963	7.5	Northeast	4.3	South	6.1
Bread	1962	4.6	Northeast	3.1	Central	3.9
	1963	4.5	South	3.8	Southwest	4.0
Potatoes	1962	11.7	South	2.6	Central	4.7
	1963	10.9	Central	3.5	Southwest	7.5
Eggs	1962	5.6	Central	0.7	Southwest	2.8
	1963	3.2	South	0.4	Central	1.0

[a] Strontium-90 results used to evaluate these ratios were taken from an earlier report (*3*).

this survey are summarized, grouping the results by six broad geographical regions of production, insofar as possible, irrespective of the market from which the food was collected. The highest concentrations of cesium-137 observed in these foods were found in evaporated and whole milk, cereals, meat, and bread.

It is concluded that the general trends of regional highs, lows, and increases in cesium-137 to potassium ratios during this study resemble those of the previously reported strontium-90 to calcium ratios for these foods. Regional variations on a harvest year basis were less discernible for meat (beef or lean pork) and eggs than for other foods.

The cesium-137 concentration and the cesium-137 to potassium ratios are generally poor indicators of strontium-90 in milk or any of the other foods tested, except as a rough estimate; however, it may be possible to apply a factor which may be suitable for estimating strontium-90 concentrations from cesium-137 data for individual foods in relatively restricted areas.

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(*1*) BUREAU OF THE CENSUS, DEPARTMENT OF COMMERCE, and DIVISION OF RADIOLOGICAL HEALTH, PUBLIC HEALTH SERVICE. National food consumption survey—fresh whole milk consumption in the United States. Rad Health Data 4:15–17 (January 1963).

(*2*) BUREAU OF THE CENSUS, DEPARTMENT OF COMMERCE, and DIVISION OF RADIOLOGICAL HEALTH, PUBLIC HEALTH SERVICE. Consumption of selected food items in U.S. households, July 1962. Rad Health Data 4:124–129 (March 1963).

(*3*) SETTER, L. R., D. SMITH, and M. SPECTOR. Strontium-90 in food—a summary of results on selected foods in the United States, July 1962–October 1963. Rad Health Data 7:64–78 (February 1966).

(*4*) MORGAN, A. F. Nutritional status U.S.A. California Agric Exp Sta Bull 769, Division of Agricultural Science, University of California, Berkeley, California.

Appendix. Cesium-137 in milk and food, July 1962–October 1963

Food	Region	Month and year	Number of samples	Cesium-137				Cesium-137/potassium, pCi/g			
				Minimum	Maximum	Median	Mean	Minimum	Maximum	Median	Mean
Milk, evaporated (concentration in pCi/kg)	Southwest	*1962*									
		Oct	10	0	112	57	58	0	43	16	19
		1963									
		Jan	10	20	200	88	92	6	67	29	29
		Apr	9	30	350	120	123	8	102	34	35
		July	10	140	310	192	205	44	90	56	60
		Oct	7	65	350	92	141	19	109	27	41
	Northwest	*1962*									
		Oct	4	40	150	107	101	13	52	41	37
		1963									
		Jan	1	—	—	—	110	—	—	—	37
		Apr	3	95	100	150	135	28	44	42	38
		Oct	3	80	390	380	283	52	120	113	105
	Central	*1962*									
		Oct	16	0	170	0	60	0	51	0	18
		1963									
		Jan	8	45	230	160	153	13	69	47	45
		Apr	11	130	200	180	177	37	64	53	52
		Oct	3	290	350	300	313	78	109	86	90
	Northeast	*1962*									
		Oct	4	130	250	155	172	35	78	40	48
		1963									
		Jan	6	25	230	140	135	7	56	39	36
		Apr	5	150	190	160	166	41	54	46	47
		July	8	140	450	335	325	39	140	113	95
		Oct	8	290	640	430	434	85	139	116	123
	South	*1962*									
		Oct	10	0	140	0	24	0	42	0	16
		1963									
		Jan	10	80	250	190	171	24	72	54	50
		Apr	3	160	250	230	213	49	78	72	66
		July	7	170	1,900	220	504	45	619	72	155
		Oct	7	130	400	225	263	44	120	71	85
	Delta	*1962*									
		Oct	4	0	240	85	102	0	70	20	28
		1963									
		Apr	3	140	190	190	173	44	64	58	55
	United States	*1962*									
		Oct	48				71.0				22.0
		1963									
		Jan	35				136.0				40.0
		Apr	3				160.0				47.0
		July	25				237.0				97.0
		Oct	28				268.0				91.0
Milk, fluid (concentration in pCi/liter)	Southwest	*1962*									
		July	13	0	95	10	27	0	67	6	18
		Oct	7	15	170	40	41	7	131	13	33
		1963									
		Jan	7	20	90	40	41	11	60	18	25
		Apr	14	0	150	57	59	0	115	35	39
		July	14	15	290	52	102	10	203	48	65
		Oct	10	30	190	50	90	18	122	37	53
	Northwest	*1962*									
		July	10	35	75	67	54	25	46	38	38
		Oct	9	55	110	70	79	36	73	44	49
		1963									
		Jan	6	0	90	82	63	0	52	42	38
		Apr	12	70	145	82	90	46	103	53	59
		July	12	130	290	205	211	73	226	149	146
		Oct	11	110	200	150	157	67	128	89	96
	Central	*1962*									
		July	24	10	80	47	50	6	53	34	35
		Oct	25	0	100	45	51	0	66	30	33
		1963									
		Jan	22	35	85	70	65	22	54	40	40
		Apr	30	0	110	65	65	26	73	42	45
		July	30	70	210	130	130	45	153	81	85
		Oct	29	60	150	90	98	33	90	53	59
	Northeast	*1962*									
		July	27	35	150	75	82	26	111	50	56
		Oct	27	0	130	70	67	0	81	44	41
		1963									
		Jan	28	45	130	75	79	31	83	45	48
		Apr	29	40	120	70	72	25	61	44	46
		July	30	120	360	200	210	72	225	134	135
		Oct	30	70	280	140	155	51	177	85	97
	South	*1962*									
		July	10	0	110	53	53	0	91	39	39
		Oct	12	20	115	45	49	15	88	31	35
		1963									
		Jan	23	0	100	55	54	0	71	39	37
		Apr	24	40	180	75	83	27	128	54	60
		July	23	45	270	140	146	30	203	88	98
		Oct	22	40	330	97	107	28	212	65	74

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Appendix—continued

Food	Region	Month and year	Number of samples	Cesium-137				Cesium-137/potassium, pCi/g			
				Minimum	Maximum	Median	Mean	Minimum	Maximum	Median	Mean
Milk, fluid—continued	Delta	*1962*									
		July	7	40	100	70	68	32	81	50	50
		Oct	4	30	55	35	39	21	39	25	28
		1963									
		Jan	7	30	75	55	52	21	54	42	38
		Apr	8	55	140	110	106	36	100	78	76
		July	8	80	170	140	136	52	112	100	91
		Oct	5	70	140	105	102	43	95	71	68
	United States	*1962*									
		July	91				58.3				40.7
		Oct	84				57.4				39.4
		1963									
		Jan	93				64.0				40.0
		Apr	117				75.0				43.0
		July	117				160.0				106.0
		Oct	110				114.0				71.0
Bread (concentration in pCi/kg)	Southwest	*1962*									
		July	8	10	55	40	26	0	91	37	45
		Oct	10	20	75	50	48	22	81	55	53
		1963									
		Jan	13	0	50	35	33	0	92	43	40
		Apr	15	30	80	45	47	33	85	53	52
		July	12	30	75	45	48	31	119	59	60
		Oct	11	60	95	75	77	81	173	119	116
	Northwest	*1962*									
		July	9	20	65	30	39	31	130	42	51
		Oct	4	25	45	38	36	28	76	56	52
	Central	*1962*									
		July	13	0	50	0	15	0	55	0	25
		Oct	20	0	60	13	21	0	94	19	27
		1963									
		Jan	10	0	90	72	64	0	95	74	68
		Apr	10	45	90	78	74	47	80	64	63
		July	20	45	90	70	69	53	96	80	72
		Oct	20	60	200	110	108	57	162	125	117
	Northeast	*1962*									
		July	10	0	0	0	0	0	0	0	0
		Oct	5	60	95	75	75	48	87	77	70
		1963									
		Jan	10	25	140	90	90	22	118	83	82
		Apr	10	60	95	85	82	47	83	73	69
		July	11	0	120	65	64	0	105	65	60
		Oct	7	65	160	90	106	103	173	123	124
	South	*1962*									
		July	16	—	—	—	—	0	100	0	16
		Oct	11	0	50	0	5	0	35	0	3
		1963									
		Jan	11	30	90	65	56	32	95	69	59
		Apr	10	20	80	53	51	20	56	42	39
		July	12	35	120	87	77	31	86	57	59
		Oct	15	65	170	120	120	60	168	107	103
	Delta	*1962*									
		July	5	0	344	0	69	0	105	0	3
	United States	*1962*									
		July	61				12.2				23.2
		Oct	50				29.5				33.2
		1963									
		Jan	44				59.0				62.0
		Apr	45				62.0				55.0
		July	55				65.0				64.0
		Oct	53				87.0				109.0
Lettuce (concentration in pCi/kg)	Southwest	*1962*									
		July	8	0	900	15	164	0	68	2	14
		Oct	9	0	50	0	6	0	19	0	2
		1963									
		Jan	15	0	35	0	2	0	8	0	1
		Apr	6	0	40	0	10	0	15	0	6
	Northwest	*1962*									
		July	5	25	65	53	47	20	35	27	26
		Oct	4	0	15	0	4	0	13	0	3
	Central	*1962*									
		July	16	0	0	0	0	0	0	0	0
		Oct	6	0	0	0	0	0	0	0	0
		1963									
		Jan	6	0	50	20	22	0	13	7	7
		Apr	4	0	0	0	0	0	0	0	0
	Northeast	*1962*									
		July	10	0	117	0	12	0	90	0	9
		Oct	6	0	0	0	0	0	0	0	0
		1963									
		Apr	1	—	—	—	0	—	—	—	0

Appendix—continued

Food	Region	Month and year	Number of samples	Cesium-137				Cesium-137/potassium, pCi/g			
				Minimum	Maximum	Median	Mean	Minimum	Maximum	Median	Mean
Lettuce—continued	South	*1962*									
		July	1	—	—	—	0	—	—	—	0
		Oct	1	—	—	—	0	—	—	—	0
		1963									
		Jan	3	0	15	0	5	0	4	0	2
		Apr	4	0	20	0	5	0	10	0	2
	United States	*1962*									
		July	40				42.0				8.0
		Oct	26				3.0				1.0
		1963									
		Jan	24				7.5				2.3
		Apr	15				6.0				2.4
Cabbage (concentration in pCi/kg)	Southwest	*1963*									
		July	4	0	0	0	0	0	0	0	0
		Oct	6	0	10	0	2	0	5	0	1
	Northwest	*1963*									
		Oct	2	0	0	0	0	0	0	0	0
	Central	*1963*									
		July	4	0	0	0	0	0	0	0	0
		Oct	11	0	15	0	3	0	9	0	1
	Northeast	*1963*									
		July	11	0	0	0	0	0	0	0	0
		Oct	13	0	75	0	10	0	28	0	4
	South	*1963*									
		July	5	0	25	15	14	0	13	8	7
	United States	*1963*									
		July	24				2.9				1.4
		Oct	32				5.3				2.4
Waste		*1963*									
		July	6	0	120	20	42	0	36	7	15
		Oct	8	0	55	30	32	0	18	9	9
Apples (concentration in pCi/kg)	Southwest	*1962*									
		July	1	—	—	—	0	—	—	—	0
		Oct	5	0	5	0	1	0	4	0	1
		1963									
		Jan	2	0	0	0	0	0	0	0	0
		Apr	2	15	15	15	15	12	14	13	13
	Northwest	*1962*									
		July	4	0	25	15	14	0	25	18	15
		Oct	4	0	0	0	0	0	0	0	0
		1963									
		Jan	5	0	60	0	15	0	42	0	12
		Apr	6	10	65	25	33	9	23	18	17
	Central	*1962*									
		July	4	0	0	0	0	0	0	0	0
		Oct	15	0	40	0	16	0	39	0	15
		1963									
		Jan	8	25	80	37	44	20	58	32	36
		Apr	4	0	30	13	14	0	26	10	14
	Northeast	*1962*									
		July	2	0	0	0	0	0	0	0	0
		Oct	15	0	55	35	35	0	68	29	37
		1963									
		Jan	10	25	80	45	46	20	70	41	40
		Apr	10	0	50	25	20	0	53	19	20
	South	*1962*									
		July	2	0	0	0	0	0	0	0	0
		Oct	8	0	0	0	0	0	0	0	0
		1963									
		Jan	4	30	45	30	34	25	37	25	28
		Apr	3	25	45	30	33	20	31	27	26
	United States	*1962*									
		July	13				4.3				4.6
		Oct	47				16.3				17.1
		1963									
		Jan	29				35.2				29.1
		Apr	25				19.0				23.0
Oranges (concentration in pCi/kg)	Southwest	*1963*									
		July	12	0	35	7	14	0	18	5	7
		Oct	9	0	20	0	8	0	11	0	4
	South	*1963*									
		July	2	45	90	68	68	22	55	38	38
		Oct	2	75	85	80	80	45	66	54	54
	United States	*1963*									
		July	14				20.0				12.0
		Oct	11				21.0				12.0

Appendix—continued

Food	Region	Month and year	Number of samples	Cesium-137 Minimum	Cesium-137 Maximum	Cesium-137 Median	Cesium-137 Mean	Cesium-137/potassium, pCi/g Minimum	Cesium-137/potassium, pCi/g Maximum	Cesium-137/potassium, pCi/g Median	Cesium-137/potassium, pCi/g Mean
Milk, fluid—continued	Delta	*1962*									
		July	7	40	100	70	68	32	81	50	50
		Oct	4	30	55	35	39	21	39	25	28
		1963									
		Jan	7	30	75	55	52	21	54	42	38
		Apr	8	55	140	110	106	36	100	78	76
		July	8	80	170	140	136	52	112	100	91
		Oct	8	70	140	105	102	43	95	71	68
	United States	*1962*									
		July	91				58.3				40.7
		Oct	84				57.4				39.4
		1963									
		Jan	93				64.0				40.0
		Apr	117				75.0				43.0
		July	117				160.0				106.0
		Oct	110				114.0				71.0
Bread (concentration in pCi/kg)	Southwest	*1962*									
		July	8	10	55	40	26	0	91	37	45
		Oct	10	20	75	50	48	22	81	55	53
		1963									
		Jan	13	0	50	35	33	0	92	43	40
		Apr	15	30	80	45	47	33	85	53	52
		July	12	30	75	45	48	31	119	59	60
		Oct	11	60	95	75	77	81	173	119	116
	Northwest	*1962*									
		July	9	20	65	30	39	31	130	42	51
		Oct	4	25	45	38	36	28	76	56	52
	Central	*1962*									
		July	13	0	50	0	15	0	55	0	25
		Oct	20	0	60	13	21	0	94	19	27
		1963									
		Jan	10	0	90	72	64	0	95	74	68
		Apr	10	45	90	78	74	47	80	64	63
		July	20	45	90	70	69	53	96	80	72
		Oct	20	60	200	110	108	57	162	125	117
	Northeast	*1962*									
		July	10	0	0	0	0	0	0	0	0
		Oct	5	60	95	75	75	48	87	77	70
		1963									
		Jan	10	25	140	90	90	22	118	83	82
		Apr	10	60	95	85	82	47	83	73	69
		July	11	0	120	65	64	0	105	65	60
		Oct	7	65	160	90	106	103	173	123	124
	South	*1962*									
		July	16	—	—	—	—	0	100	0	16
		Oct	11	0	50	0	5	0	35	0	3
		1963									
		Jan	11	30	90	65	56	32	95	69	59
		Apr	10	20	80	53	51	20	56	42	39
		July	12	35	120	87	77	31	86	57	59
		Oct	15	65	170	120	120	60	108	107	103
	Delta	*1962*									
		July	5	0	344	0	69	0	105	0	3
	United States	*1962*									
		July	61				12.2				23.2
		Oct	50				29.5				33.2
		1963									
		Jan	44				59.0				62.0
		Apr	45				62.0				55.0
		July	55				65.0				64.0
		Oct	53				87.0				109.0
Lettuce (concentration in pCi/kg)	Southwest	*1962*									
		July	8	0	900	15	164	0	68	2	14
		Oct	9	0	50	0	6	0	19	0	2
		1963									
		Jan	15	0	35	0	2	0	8	0	1
		Apr	6	0	40	0	10	0	15	0	6
	Northwest	*1962*									
		July	5	25	65	53	47	20	35	27	26
		Oct	4	0	15	0	4	0	13	0	3
	Central	*1962*									
		July	16	0	0	0	0	0	0	0	0
		Oct	6	0	0	0	0	0	0	0	0
		1963									
		Jan	6	0	50	20	22	0	13	7	7
		Apr	4	0	0	0	0	0	0	0	0
	Northeast	*1962*									
		July	10	0	117	0	12	0	90	0	9
		Oct	6	0	0	0	0	0	0	0	0
		1963									
		Apr	1	—	—	—	0	—	—	—	0

Appendix—continued

Food	Region	Month and year	Number of samples	Cesium-137				Cesium-137/potassium, pCi/g			
				Minimum	Maximum	Median	Mean	Minimum	Maximum	Median	Mean
Oranges—continued Waste		*1963*									
		July	8	25	120	62	64	8	65	39	36
		Oct	3	55	240	70	122	31	99	32	57
Eggs (concentration in pCi/kg)	Southwest	*1963*									
		Jan	8	0	0	0	0	0	0	0	0
		Apr	12	0	20	5	7	0	15	3	5
		July	4	0	15	0	4	0	11	0	3
		Oct	5	5	15	10	10	3	10	7	7
	Central	*1963*									
		Jan	6	0	20	10	9	0	14	12	7
		Apr	6	0	55	5	14	0	37	5	11
		July	8	0	30	0	6	0	22	0	5
		Oct	6	0	25	0	8	0	17	0	5
	Northeast	*1963*									
		Jan	7	0	35	15	16	0	22	9	13
		Apr	6	0	25	10	12	0	16	7	8
		July	9	0	0	0	0	0	0	0	0
		Oct	8	0	0	0	0	0	0	0	0
	South	*1963*									
		Jan	6	0	10	0	3	0	9	3	3
		Apr	3	0	20	10	10	0	16	7	7
		July	5	10	20	10	13	7	15	8	10
		Oct	6	0	20	15	13	0	15	10	9
	United States	*1963*									
		Jan	27				7.0				6.0
		Apr	27				10.0				7.3
		July	26				5.4				4.0
		Oct	25				7.5				5.0
Beef (concentration in pCi/kg)	Southwest	*1962*									
		July	3	30	140	80	83	12	53	42	36
		Oct	2	20	35	27	28	9	15	12	12
		1963									
		Jan	4	25	60	30	37	14	33	16	20
		Apr	4	25	85	68	61	10	40	26	25
	Northwest	*1963*									
		Jan	1	—	—	—	80	—	—	—	26
	Central	*1962*									
		July	3	0	45	0	15	0	18	0	6
		Oct	7	0	90	30	32	0	38	13	13
		1963									
		Jan	6	0	240	60	82	0	110	28	36
		Apr	8	0	120	60	64	0	56	26	31
	Northeast	*1962*									
		July	2	0	0	0	0	0	0	0	0
	South	*1962*									
		July	5	35	290	40	95	0	131	16	46
		Oct	5	0	130	25	47	0	64	13	22
		1963									
		Jan	2	15	65	40	40	7	30	18	18
	United States	*1962*									
		July	13				59.0				27.0
		Oct	14				37.0				16.0
		1963									
		Jan	13				61.0				28.0
		Apr	12				64.0				29.0
Pork (concentration in pCi/kg)	Southwest	*1963*									
		July	3	30	90	75	65	20	44	38	35
		Oct	2	110	140	125	125	59	62	60	60
	Central	*1963*									
		July	11	35	440	110	120	19	132	47	53
		Oct	15	55	500	130	171	17	187	51	59
	South	*1963*									
		July	7	60	170	120	119	26	62	43	42
		Oct	8	45	240	140	133	18	110	54	51
	United States	*1963*									
		July	20				112.0				46.0
		Oct	32				154.0				73.0
Waste—bone		*1963*									
		July	9	0	180	65	84	0	132	43	26
		Oct	13	25	85	50	67	12	87	29	37
Potatoes (concentration in pCi/kg)	Southwest	*1963*									
		Jan	2	0	30	15	15	2	6	4	4
		Apr	4	0	20	15	13	0	5	4	3
		July	16	0	40	0	10	0	11	0	3
		Oct	4	0	50	15	20	0	11	5	5

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Appendix—continued

Food	Region	Month and year	Number of samples	Cesium-137				Cesium-137/potassium, pCi/g			
				Minimum	Maximum	Median	Mean	Minimum	Maximum	Median	Mean
Potatoes—Continued	Northwest	*1963*									
		Jan	5	0	35	20	19	0	7	4	4
		Apr	4	0	25	0	6	0	5	0	2
		Oct	7	10	250	20	52	3	66	6	13
	Central	*1963*									
		Jan	3	0	20	10	10	0	4	2	2
		Apr	9	0	20	0	3	0	5	0	1
		Oct	12	20	85	40	47	5	19	11	11
	Northeast	*1963*									
		Jan	8	0	55	25	24	0	13	6	6
		Apr	8	0	20	0	7	0	5	0	2
		July	6	0	75	0	15	0	17	0	4
		Oct	10	45	75	65	60	10	18	14	13
	South	*1963*									
		Apr	2	35	35	35	35	7	8	8	8
		July	9	25	110	60	55	6	28	12	12
	United States	*1963*									
		Jan	18				20.0				4.7
		Apr	27				8.5				2.4
		July	31				24.0				6.0
		Oct	33				49.0				12.0
Waste		*1963*									
		July	9	0	90	40	38	7	21	8	8
		Oct	5	25	110	45	57	5	20	10	11
Oleomargarine (concentration in pCi/kg)	Southwest	*1963*									
		Jan	7	0	0	0	0	0	0	0	0
		Apr	6	0	25	0	4	0	66	0	13
	Central	*1963*									
		Jan	3	0	15	10	8	0	31	26	16
		Apr	9	0	15	0	3	0	47	0	9
	Northeast	*1963*									
		Jan	8	10	35	20	23	27	95	64	64
		Apr	4	0	0	0	0	0	0	0	0
	South	*1963*									
		Jan	11	0	20	10	7	0	60	30	17
		Apr	8	0	30	10	9	0	66	26	27
	United States	*1963*									
		Jan	29				10.0				26.7
		Apr	27				4.4				13.8
Cereal		*1963*									
Corn		July	8	0	50	0	6	0	28	0	6
		Oct	7	0	50	0	14	0	48	0	15
Wheat		July	9	40	250	150	156	13	92	53	59
		Oct	11	75	770	250	296	52	164	101	98
Oats		July	4	0	350	175	142	0	95	57	63
		Oct	4	200	280	215	228	60	106	79	80
Rice		July	8	0	130	30	38	0	63	35	33
		Oct	5	0	120	30	37	0	165	34	56
Wheat, malted		July	3	110	150	140	133	46	58	47	50
		Oct	2	150	240	195	195	98	98	98	98
Bran		July	2	150	490	320	320	28	39	38	38
		Oct	4	160	810	277	381	19	80	35	45
	United States	*1963*									
		July	34				99.0				36.0
		Oct	33				193.0				61.0

Data

Section I. Milk and Food

In the determination of the internal exposure to man from environmental radiation sources, primary interest centers on radionuclides in the diet. Efforts are being made by both Federal and State agencies to monitor the intake of various radionuclides in the total diet on a continuing basis. Although the total diet is the most direct measure of intake of radionuclides, indicator foods may be used to estimate dietary intake where specific dietary data are not available. As fresh milk is consumed by a large segment of the U.S. population and contains most of the biologically significant radionuclides from nuclear test debris which appear in the diet, it is the single food item most often used as an indicator of the population's intake of radionuclides. Moreover, it is the major source of dietary intake of short-lived radionuclides. In the absence of specific dietary information, it is possible to approximate the total daily dietary intake of selected radionuclides as being equivalent to the intake represented by the consumption of 1 liter of milk. More direct estimates of dietary intake of radionuclides than those furnished by indicator foods can be obtained by analyses of the total diet or representative principal food items or groups combined with appropriate consumption data.

The Federal Radiation Council has developed Radiation Protection Guides (RPG's) for controlling normal peacetime operations, assuming continuous exposure from intake by the population at large (*1–3*). The RPG's do not and cannot establish a line which is safe on one side and unsafe on the other; they do provide an indication of when there is a need to initiate careful evaluation of exposure (*3*). Additional guidelines are provided by the International Commission on Radiological Protection (*4, 5*).

Data from selected National, International, and State milk and food surveillance activities are presented herein. An effort has been made to present a cross section of routine sampling programs which may be considered of a continuing nature. Routine milk sampling has been defined as one or more samples collected per month.

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(*4*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 2. Pergamon Press (1959).

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NATIONAL AND INTERNATIONAL MILK SURVEILLANCE

As part of continuing efforts to quantitatively monitor man's exposure to radionuclides, various National and International organizations routinely monitor radionuclide levels in milk. Data from the Pasteurized Milk Network (U.S.), Canadian Milk Network, Pan American Milk Network, and the HASL milk program are presented below.

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1. Pasteurized Milk Network
November 1965

Division of Radiological Health
and Division of Environmental
Engineering and Food Protection, PHS

The Public Health Service's Pasteurized Milk Network (PMN) was designed to provide nationwide surveillance of radionuclide concentrations in milk through sampling from major milk production and consumption areas. The present network of 63 sampling stations (figure 1) provides data on milk in every State. In addition, milk is sampled in the Canal Zone and Puerto Rico. The most recent description of the sampling and analytical procedures employed by the PMN appeared in the December 1965 issue of *Radiological Health Data (1)*.

The results for November 1965 and third quarter of 1965 are presented in table 1. The average monthly radionuclide concentrations are based on results obtained from samples

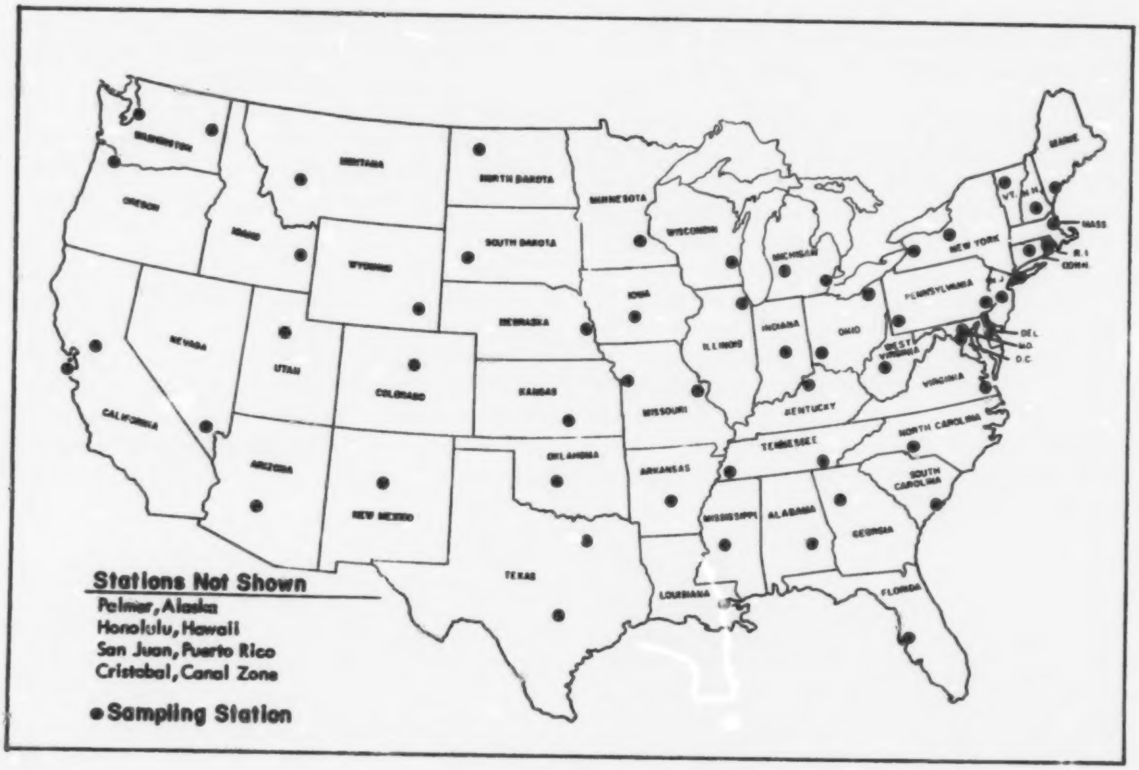
WASHINGTON
OREGON
CALIFORNIA
IDAHO
NEVADA
MONTANA
WYOMING
UTAH
ARIZONA
COLORADO
NEW MEXICO
NORTH DAKOTA
SOUTH DAKOTA
NEBRASKA
KANSAS
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
WISCONSIN
ILLINOIS
MICHIGAN
INDIANA
OHIO
KENTUCKY
TENNESSEE
MISSISSIPPI
ALABAMA
GEORGIA
FLORIDA
SOUTH CAROLINA
NORTH CAROLINA
VIRGINIA
WEST VIRGINIA
PENNSYLVANIA
NEW YORK
N.J.
DEL.
MD.
D.C.
CONN.
R.I.
MASS.
VT.
N.H.
MAINE
Stations Not Shown
Palmer, Alaska
Honolulu, Hawaii
San Juan, Puerto Rico
Cristobal, Canal Zone
● Sampling Station

Figure 1. Pasteurized Milk Network sampling locations

Table 1. Average concentrations of stable elements and radionuclides in pasteurized milk for the third quarter and November 1965 [a]

Sampling locations		Calcium (g/liter)		Strontium-89 (pCi/liter)		Strontium-90 (pCi/liter)		Cesium-137 (pCi/liter)	
		Third quarter	Average for November	Third quarter	Average for November	Third quarter	Average for November	Third quarter	Average for November
Ala:	Montgomery	1.14	1.16	<5	<5	14	15	40	30
Alaska:	Palmer	1.22	1.27	<5	<5	15	12	50	40
Ariz:	Phoenix	1.22	1.26	<5	<5	4	5	20	15
Ark:	Little Rock	1.14	1.20	5	<5	28	27	50	25
Calif:	Sacramento	1.28	1.24	<5	<5	5	5	25	20
	San Francisco	1.25	1.28	<5	<5	5	4	20	15
C. Z:	Cristobal	1.10	1.13	<5	<5	4	4	30	35
Colo:	Denver	1.28	1.27	5	<5	14	11	40	20
Conn:	Hartford	1.09	1.12	<5	<5	13	13	50	40
Del:	Wilmington	1.11	1.14	<5	<5	15	13	40	35
D. C:	Washington	1.13	1.18	<5	<5	13	14	30	25
Fla:	Tampa	1.10	1.17	<5	<5	12	16	175	140
Ga:	Atlanta	1.14	1.17	<5	<5	20	19	55	45
Hawaii:	Honolulu	1.16	1.16	<5	<5	6	7	40	40
Idaho:	Idaho Falls	1.27	1.27	<5	<5	16	14	50	40
Ill:	Chicago	1.11	1.14	<5	<5	11	11	35	35
Ind:	Indianapolis	1.11	1.17	<5	<5	12	11	25	25
Iowa:	Des Moines	1.23	1.26	<5	<5	16	16	30	15
Kans:	Wichita	1.19	1.26	<5	<5	14	13	25	15
Ky:	Louisville	1.12	1.15	5	<5	18	16	25	20
La:	New Orleans	1.18	1.21	<5	<5	33	31	60	40
Maine:	Portland	1.11	1.13	5	<5	20	18	90	65
Md:	Baltimore	1.11	1.17	<5	<5	15	15	40	30
Mass:	Boston	1.10	1.15	5	<5	19	16	80	60
Mich:	Detroit	1.09	1.13	<5	<5	11	11	35	30
	Grand Rapids	1.13	1.17	<5	<5	14	14	45	40
Minn:	Minneapolis	1.28	1.26	5	<5	23	22	50	40
Miss:	Jackson	1.18	1.22	<5	<5	25	25	40	25
Mo:	Kansas City	1.21	1.22	5	<5	18	17	25	15
	St. Louis	1.22	1.32	5	<5	16	20	25	15
Mont:	Helena	1.27	1.26	5	<5	18	16	55	40
Nebr:	Omaha	1.22	1.25	<5	<5	16	18	30	25
Nev:	Las Vegas	1.20	1.21	<5	<5	5	6	20	20
N. H:	Manchester	1.11	1.14	<5	<5	21	18	105	65
N. J:	Trenton	1.09	1.14	<5	<5	14	11	40	25
N. Mex:	Albuquerque	1.24	1.22	<5	<5	6	6	20	10
N. Y:	Buffalo	1.09	1.10	<5	<5	11	12	45	45
	New York	1.09	1.10	<5	<5	17	14	55	35
	Syracuse	1.09	1.10	5	<5	12	12	40	40
N. C:	Charlotte	1.13	1.17	<5	<5	24	27	40	25
N. Dak:	Minot	1.28	1.26	10	<5	31	30	55	40
Ohio:	Cincinnati	1.11	1.13	<5	<5	13	13	25	20
	Cleveland	1.10	1.15	5	<5	13	12	35	25
Okla:	Oklahoma City	1.11	1.18	<5	<5	14	14	25	20
Ore:	Portland	1.28	1.27	<5	<5	14	13	50	45
Pa:	Philadelphia	1.08	1.10	<5	<5	13	11	35	30
	Pittsburgh	1.11	1.14	5	<5	20	18	50	35
P. R:	San Juan	1.13	1.10	<5	<5	9	9	40	25
R. I:	Providence	1.10	1.15	<5	<5	16	15	65	40
S. C:	Charleston	1.14	1.19	<5	<5	23	27	70	55
S. Dak:	Rapid City	1.04	1.18	10	<5	20	22	50	45
Tenn:	Chattanooga	1.16	1.24	<5	<5	26	22	40	30
	Memphis	1.15	1.17	5	<5	20	18	25	20
Tex:	Austin	1.12	1.15	<5	<5	5	5	20	10
	Dallas	1.11	1.15	<5	<5	12	13	25	20
Utah:	Salt Lake City	1.36	1.36	<5	<5	12	11	55	35
Vt:	Burlington	1.11	1.09	<5	<5	17	14	65	55
Va:	Norfolk	1.13	1.16	<5	<5	17	17	40	25
Wash:	Seattle	1.28	1.28	<5	<5	18	17	70	45
	Spokane	1.33	1.28	<5	<5	18	17	50	40
W. Va:	Charleston	1.12	1.14	<5	<5	18	16	25	20
Wis:	Milwaukee	1.17	1.18	<5	<5	11	11	40	40
Wyo:	Laramie	1.28	1.23	<5	<5	14	25	50	40
Network average		1.16	1.19	<5	<5	15.3	15.0	44	34

[a] All iodine-131 and barium-lanthanum-140 values were below detectable levels.

Table 2. Frequency distribution, strontium-90 concentrations in milk at Pasteurized Milk Network Stations, June–November 1965 and November 1964

Strontium-90 (pCi/liter)	Number of stations						
	1965						1964
	June	July	Aug	Sep	Oct	Nov	Nov
Under 10	7	8	10	11	8	9	6
10–19	21	34	41	44	46	43	31
20–29	29	18	11	7	7	9	19
30–39	4	3	1	1	2	2	6
40–49	2	0	0	0	0	0	1
50–59	0	0	0	0	0	0	0

collected weekly. If radionuclide values were below minimum detectable concentrations (*1*), averages were calculated using one-half the minimum detectable value; however, for iodine-131 and barium-140, zero was used for averaging purposes when concentrations were below minimum detectable levels.

Table 3. Frequency distribution, cesium-137 concentrations in milk at Pasteurized Milk Network stations, June–November 1965 and November 1964

Cesium-137 (pCi/liter)	Number of stations						
	1965						1964
	June	July	Aug	Sep	Oct	Nov	Nov
Under 50	19	34	45	50	54	57	15
50–99	38	25	16	12	8	5	41
100–149	5	3	1	0	0	1	4
150–199	1	1	1	1	1	0	2
200–249	0	0	0	0	0	0	1
250–299	0	0	0	0	0	0	0

For comparative purposes, distributions of strontium-90 and cesium-137 are presented in tables 2 and 3 for June through November 1965 and November 1964. The average strontium-90 concentrations in pasteurized milk from selected cities of the network are plotted in figure 2.

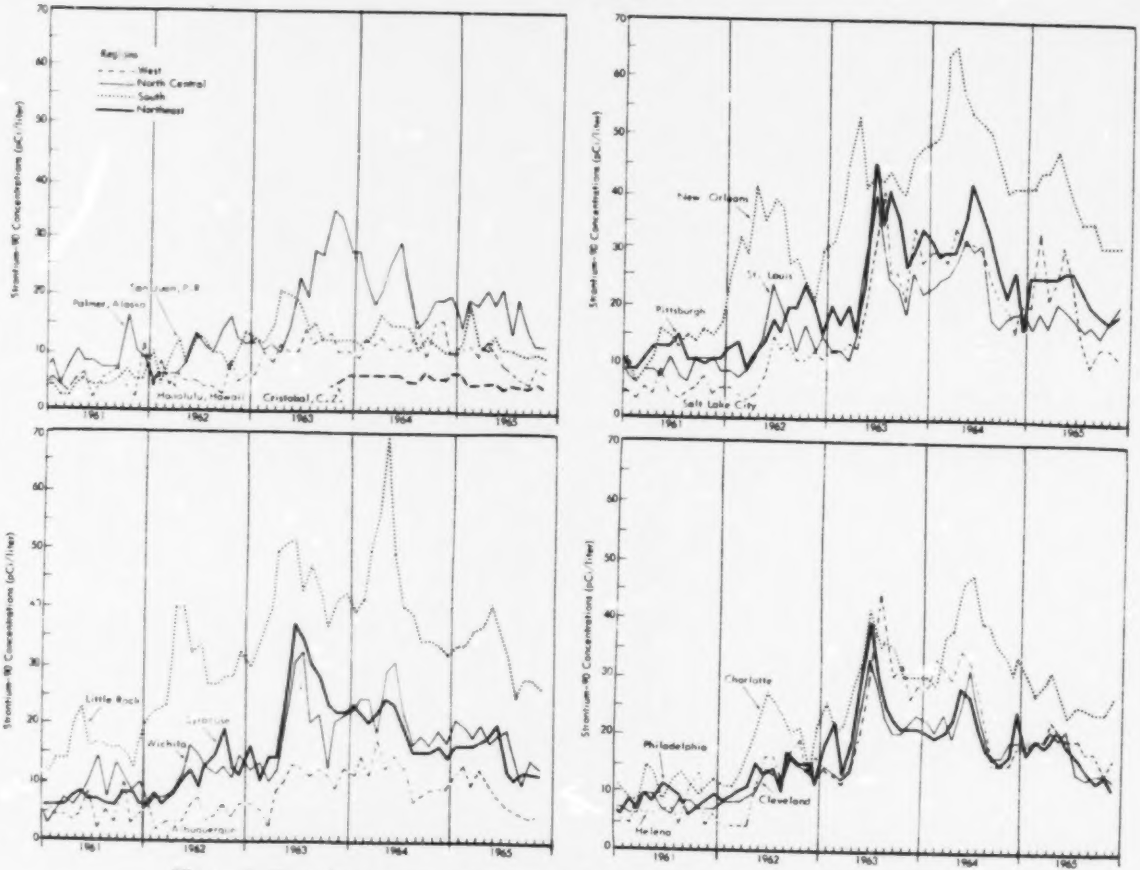

Figure 2. Strontium-90 concentrations in pasteurized milk, 1961–November 1965

2. Canadian Milk Network
November 1965 [1]

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

Since November 1955, the Radiation Protection Division of the Department of National Health and Welfare has been monitoring milk for radionuclide concentrations. Powdered milk was originally sampled, but liquid whole milk has been sampled since January 1963. At present 16 milk sampling stations (figure 3) are in operation. Their locations coincide with air and precipitation sampling stations.

Milk samples are collected three times a week from selected dairies and are combined into weekly composites. The contribution of each dairy to the composite sample is directly proportional to the liquid volume of sales. Weekly spot check analyses are made for iodine–131, and monthly composites are analyzed for strontium–90, cesium–137, and stable calcium and potassium. The analytical procedures were outlined in the December 1965 issue of *Radiological Health Data* (*2*).

The November 1965 monthly average strontium–90, cesium–137, and stable calcium and potassium concentrations in Canadian whole milk are presented in table 4. Iodine–131 and strontium–89 concentrations were below minimum detectable levels.

Table 4. Stable elements and radionuclides in Canadian whole milk, November 1965

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90 (pCi/liter)	Cesium-137 (pCi/liter)
Calgary	1.13	1.6	20.2	60
Edmonton	1.12	1.6	18.3	58
Ft. William	1.11	1.6	33.4	79
Fredericton	1.14	1.6	26.8	80
Halifax	1.11	1.6	24.6	71
Montreal	NA	1.6	NA	41
Ottawa	1.14	1.6	14.9	38
Quebec	1.11	1.6	25.6	76
Regina	1.14	1.6	15.7	38
St. John's, Nfld	1.03	1.4	21.0	84
Saskatoon	1.15	1.6	20.0	37
Sault Ste. Marie	1.03	1.6	26.5	74
Toronto	1.15	1.6	7.2	32
Vancouver	1.19	1.5	22.5	100
Windsor	1.15	1.5	10.4	22
Winnipeg	1.06	1.5	18.7	57
Average	1.12	1.6	20.3	59

NA, no analysis

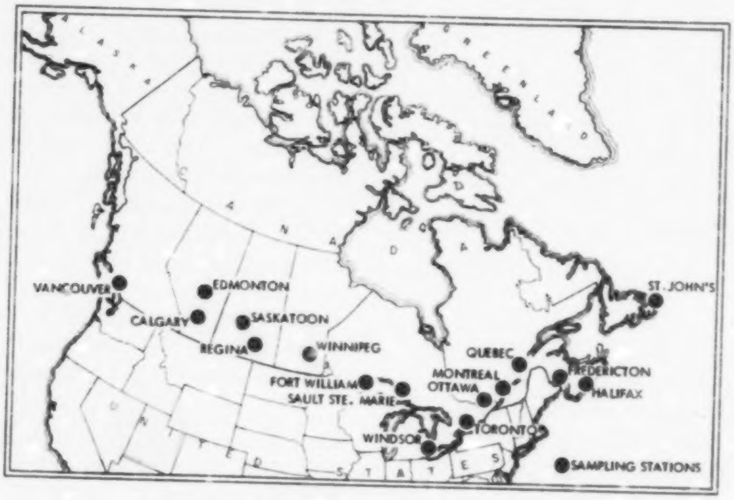

Figure 3. Canadian milk sampling stations

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[1] Prepared from December 1965 monthly report, "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Pan American Milk Sampling Program November 1965

Pan American Health Organization and Public Health Service

The Pan American Health Organization (PAHO), in collaboration with the Public Health Service (PHS), furnishes assistance to health agencies in the American Republics in developing national radiological health programs.

Under a joint agreement between both agencies, air and milk sampling activities are conducted by a number of PAHO member countries (figure 4). Results of the milk sampling program are presented below. Further information on the sampling and analytical procedures employed was presented in the December 1965 issue of *Radiological Health Data* (3).

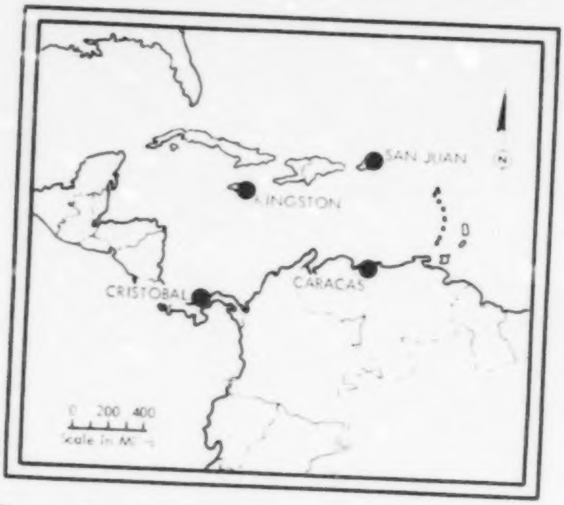

Figure 4. Pan American Milk Network sampling locations

Table 5 presents stable calcium and potassium, strontium-90, strontium-89, and cesium-137 monthly average concentrations. The monthly average iodine-131 and barium-140 concentrations in milk were less than 10 pCi/liter.

Table 5. Stable element and radionuclide concentrations in PAHO milk, November 1965

Sampling station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89 (pCi/liter)	Strontium-90 (pCi/liter)	Cesium 137 (pCi/liter)
Canal Zone:					
Cristobal	1.13	1.4	<5	4	35
Jamaica:					
Kingston	NS	NS	NS	NS	NS
Mandeville	1.09	1.31	<5	9	180
Montego Bay	NS	NS	NS	NS	NS
Puerto Rico:					
San Juan	1.10	1.5	<5	9	25
Venezuela:					
Caracas	1.19	1.35	<5	4	10

NS, no sample collected.

4. Radiostrontium in milk April–June 1965[2]

Health and Safety Laboratory U.S. Atomic Energy Commission

In 1954, the Health and Safety Laboratory began monitoring strontium-90 in liquid whole milk in New York City to estimate the dietary contribution from ingestion of radiostrontium in milk. Subsequently, powdered milk monitoring was initiated at Perry, New York (1954), and at Mandan, North Dakota (1955). Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Honolulu samples are monthly composites of quart samples of pasteurized milk collected weekly. Samples from two dairies are analyzed and the results are averaged. The Mandan and Perry samples are monthly composites of powdered milk collected in 5-pound lots from plants in each city. The Mandan sample is powdered buttermilk used in cattle feeds. Because of its protein and fat content, this buttermilk powder is used primarily as a milk replacer or feed supplement for calves. The Perry sample is powdered whole milk used for human consumption. The source of the Honolulu milk is a herd on the island of Oahu where the cows are on pasture throughout the year.

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[2] Data summarized from "Fallout Program Quarterly Summary Report, HASL-165," available from Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Virginia 22151.

Results

The calcium and strontium-90 concentrations in liquid whole milk are given in table 6, and presented graphically in figure 5. Strontium-90 and calcium results for powdered milk and powdered buttermilk are shown in tables 7 and 8. The strontium-90 results for powdered milk and buttermilk are shown in figure 6.

Table 6. Strontium-90 and calcium in liquid milk, January–June 1965, and annual average strontium-90 concentrations in milk, 1959–1964

Sampling station and periods	Calcium concentration (g/liter)	Strontium-90 concentration (pCi/liter)	Strontium-90/ calcium ratio (pCi/g)
New York City			
1959 average			11
1960 average			8.0
1961 average			6.7
1962 average			12
1963 average			26
1964 average			23
1965			
January	1.03	21.4	20.8
February	1.02	18.4	18.0
March	1.01	21.4	21.1
April	1.04	19.8	19.0
May	1.02	23.3	22.9
June	1.15	20.7	18.0
Honolulu, Hawaii			
1959 average			5.0
1960 average			3.2
1961 average			2.4
1962 average			4.3
1963 average			8.0
1964 average			8.6
1965			
January	1.04	8.2	7.9
February	1.02	7.8	7.6
March	1.00	8.8	8.9
April	1.03	7.8	7.6
May	1.07	7.2	6.8
June	1.19	5.4	4.6

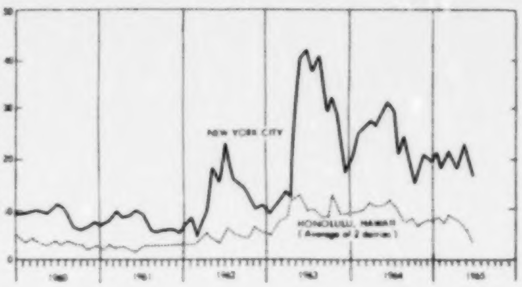

Figure 5. Strontium-90 in liquid milk samples, Honolulu, Hawaii, and New York City, 1960–June 1965

Table 7. Strontium-90 and calcium in powdered milk, January–June 1965, and annual average strontium-90 concentrations in powdered milk, 1959–1964

Sampling station and month	Calcium concentration (g/kg)	Strontium-90 concentration (pCi/kg)	Strontium-90/ calcium ratio (pCi/g)
Perry, New York			
1959 average			8.0
1960 average			6.5
1961 average			6.2
1962 average			11.1
1963 average			21.6
1964 average			20.4
1965			
January	9.33	166	17.7
February	8.51	121	14.2
March	8.73	166	19.0
April	8.58	157	18.3
May	8.72	148	16.9
June	10.0	134	13.3

Table 8. Strontium-90 and calcium in powdered buttermilk, January–June 1965, and annual average strontium-90/calcium ratios in buttermilk, 1959–1964

Sampling station and month	Calcium concentration (g/kg)	Strontium-90 concentration (pCi/kg)	Strontium-90/ calcium ratio (pCi/g)
Mandan, North Dakota			
1959 average			26
1960 average			15
1961 average			9.4
1962 average			25
1963 average			58
1964 average			62.7
1965			
January	10.8	594	54.6
February	10.4	522	50.0
March	10.8	699	61.8
April	11.2	680	60.7
May	8.9	588	66.3
June	12.7	411	32.4

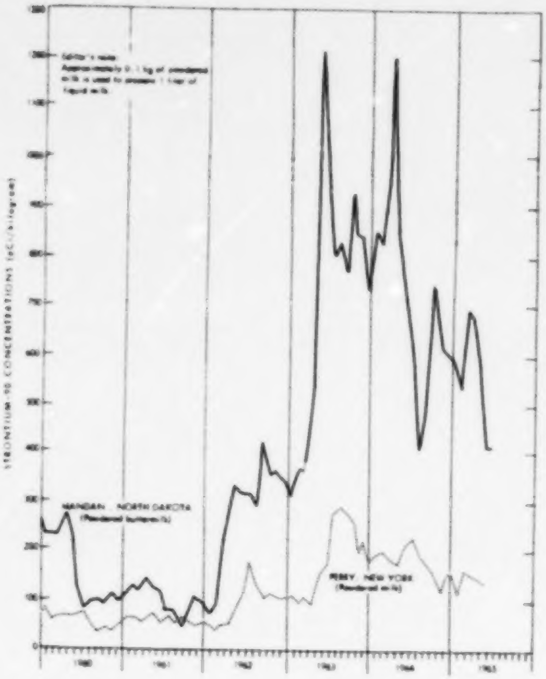

Figure 6. Strontium-90 in powdered milk samples, Perry, New York, and Mandan, North Dakota 1960–June 1965

REFERENCES

(1) U.S. PUBLIC HEALTH SERVICE. Milk surveillance, Pasteurized Milk Network, August 1965. Rad Health Data 6:677–681 (December 1965).

(2) RADIATION PROTECTION DIVISION, DEPARTMENT OF NATIONAL HEALTH AND WELFARE, OTTAWA, CANADA. Canadian Milk Network, August 1965. Rad Health Data 6:685–686 (December 1965).

(3) PAN AMERICAN HEALTH ORGANIZATION and PUBLIC HEALTH SERVICE. Pan American Milk Sampling Program, August 1965. Rad Health Data 6:687 (December 1965).

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
April–June 1963	*January 1964*
July–September 1963	*April 1964*
October–December 1963	*July 1964*
January–December 1964	*June 1965*
January–March 1965	*September 1965*

STATE MILK SURVEILLANCE ACTIVITIES

Considerable progress has been made by the State health departments in initiating or expanding environmental surveillance activities in radiological health. Many of the States have progressed to a state of comprehensive environmental surveillance programs and self-sustaining radiological health laboratories.

The continuing efforts of State health departments in the analysis and monitoring of radionuclides in milk complement Federal milk surveillance activities. State milk surveillance activities are continually undergoing developmental changes at present. The results presented herein, while not inclusive, are representative of current surveillance activities directed at the use of milk as an indicator of dietary intake of radioactivity.

Reports of State milk surveillance activities appeared in the following previous issues of *Radiological Health Data and Reports:*

Program	Period reported	Last presented
Colorado Milk Network	October–December 1964	April 1965
Connecticut Milk Network	April–September 1965	February 1966
Florida Milk Network	January–June 1965	January 1966
Indiana Milk Network	July–September 1965	February 1966
Michigan Milk Network	July–September 1965	February 1966
Minnesota Milk Network	January–June 1965	January 1966
New York Milk Network	April–June 1965	January 1966
Oklahoma Milk Network	March–July 1965	October 1965
Pennsylvania Milk Network	July–September 1965	February 1966
Texas Milk Network	January–March 1965	October 1965

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1. California Milk Network
July–September 1965

Division of Environmental Sanitation
State of California
Department of Public Health

Surveillance of specific radionuclides in milk is one phase of California's Department of Health program of radiation control. This milk monitoring function has been conducted at eight milksheds since January 1960 by the Department's Bureau of Radiological Health. With the addition of the Del Norte and Mendocino milksheds to the program in March 1962, weekly, biweekly, or monthly sampling of pasteurized milk has been conducted at 10 major milksheds (figure 1). The original sampling locations were chosen by the State Department of Agriculture so as to be representative of milk consumed by a high percentage of the State's population. A description of the various California milksheds was presented earlier by Heslep and Cornish (*1*).

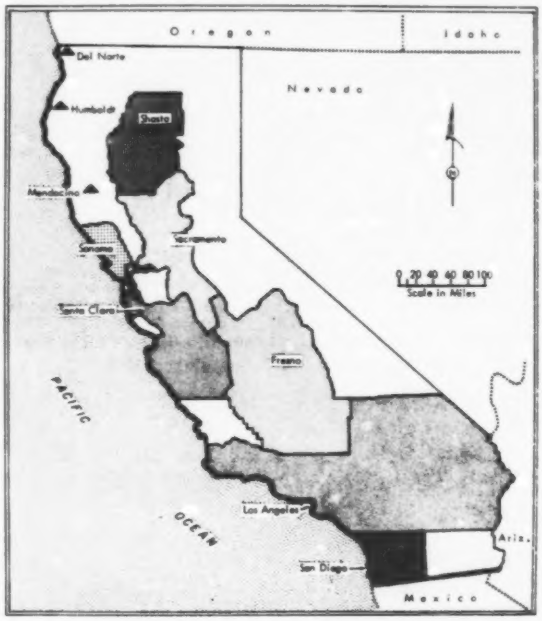

Figure 1. California milksheds

Strontium-89 and strontium-90 concentrations are determined radiochemically. Potassium-40, iodine-131, cesium-137, and barium-140 in whole fluid milk are determined by gamma-scintillation spectrometry. A detailed description of the analytical procedures was presented earlier (*2*).

The monthly calcium and radionuclide concentrations in California pasteurized milk are given in table 1 for the period July to September 1965.

Network average strontium-90 and cesium-137 concentrations are presented graphically in figure 2. Superimposed upon normal seasonal variations is a decreasing trend since the peak which occurred in the spring of 1963.

Table 1. Stable elements and radionuclides in California milk, July-September 1965

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium (g/liter)											
July	1.37	1.16	1.23	1.11	1.20	1.00	1.12	1.15	1.10	1.31	1.17
August	1.38	1.23	1.21	1.10	1.15	1.17	1.11	1.12	1.12	1.20	1.18
September	1.27	1.25	1.31	1.14	1.28	1.26	1.15	1.16	1.21	1.27	1.23
Potassium-40 (pCi/liter)											
July	1,132	1,110	1,158	1,201	1,319	1,133	1,250	1,158	1,237	1,260	1,196
August	1,189	1,157	1,157	NA	1,351	1,262	1,230	1,161	1,177	1,237	1,213
September	1,089	1,212	1,183	1,203	1,281	1,232	1,212	1,200	1,157	1,257	1,002
Strontium-89 (pCi/liter)											
July	•2.3	NA	1.5	NA	NA	•0.9	ND	•2.1	ND	ND	0.9
August	0.9	ND	ND	•0.14	ND	•2.4	1.1	•0.9	ND	•0.3	0.4
September	1.6	ND	ND	0.2	ND	•1.0	ND	ND	0.7	ND	0.3
Strontium-90 (pCi/liter)											
July	33	5.3	8.7	3.6	6.7	3.9	2.9	3.4	0.8	7.9	7.6
August	22	3.7	10.	2.4	5.3	3.5	1.7	5.0	0.8	6.2	6.1
September	14	2.9	6.4	2.7	4.4	3.9	2.6	2.8	0.5	4.7	4.5
Cesium-137 (pCi/liter)											
July	47	14	11	20	14	18	17	24	23	33	22
August	40	17	19	NA	22	21	•13	22	27	33	24
September	23	17	12	20	18	21	18	15	28	24	20

NA, No analysis performed.
ND, Below detectable level.
• When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best available estimate, but is not statistically significant. Where no value is given, no activity was detected.

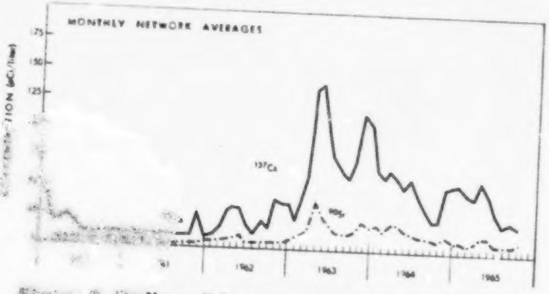

Figure 2. Radionuclide concentrations in California milk network, 1960–September 1965

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1963	*March 1964*
October–December 1963	*June 1964*
January–March 1964	*September 1964*
April–June 1964	*December 1964*
July–September 1964	*March 1965*
October–December 1964	*June 1965*
January–March 1965	*September 1965*
April–June 1965	*December 1965*

2. Oregon Milk Network
July–September 1965 [1]

Division of Sanitation and Engineering
Oregon State Board of Health

The Oregon State Board of Health has monitored radionuclide concentrations in milk since March 1962. As part of this program routine milk samples are collected at eight major production areas (figure 3), which supply 90 percent of the milk distributed in the State. Currently, pasteurized milk samples are collected monthly except in the Portland area where weekly samples are collected by the city of Portland. The milk sampling frequency is accelerated to a weekly basis in areas where iodine–131 concentrations exceed 100 pCi/liter, or where cesium–137 concentrations exceed 500 pCi/liter. Strontium–90 analyses are performed on a bimonthly basis, but may be done monthly when significant increases are observed.

Strontium–90 concentrations are determined using a trichloracetic acid analytical procedure (*3*). Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma-scintillation spectrometry (*4*).

Table 2 gives the strontium–90 and cesium–137 concentration in pasteurized milk from July through September 1965. These data are presented graphically in figure 4. Iodine–131 and barium–140 concentrations remained below minimum detectable levels.

Table 2. Radionuclide concentrations in Oregon milk, July–September 1965 (pCi/liter)

Sampling locations	Sampling frequency	Strontium-90			Cesium-137		
		July	Aug	Sep	July	Aug	Sep
Baker	M	16	NA	11	65	60	40
Coos Bay	M	25	NA	12	75	60	35
Eugene	M	10	NA	11	35	30	35
Medford	M	11	NA	11	85	35	30
Nyssa	M	17	NA	19	60	50	30
Portland composite	W	15	13	16	55	45	50
Portland local	W	24	NA	15	65	70	50
Redmond	M	13	NA	10	50	60	60
Tillamook	M	38	NA	26	105	65	80
Average	—	19	13	15	66	55	40

Key to symbols: M, sampled monthly
W, sampled weekly
NA, no analysis

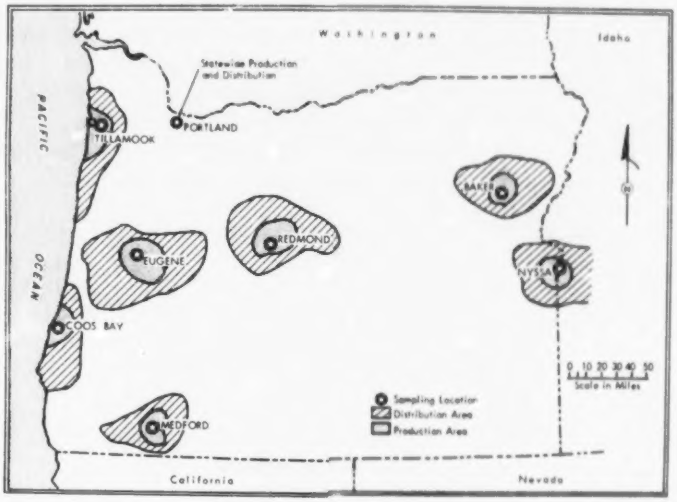
Washington
Idaho
PACIFIC
OCEAN
Statewide Production and Distribution
PORTLAND
TILLAMOOK
BAKER
REDMOND
EUGENE
NYSSA
COOS BAY
MEDFORD
0 10 20 30 40 50
Scale in Miles
Sampling Location
Distribution Area
Production Area
California
Nevada

Figure 3. Oregon milksheds

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[1] This work was summarized under the supervision of George L. Toombs, chief radiochemist, Oregon State Board of Health.

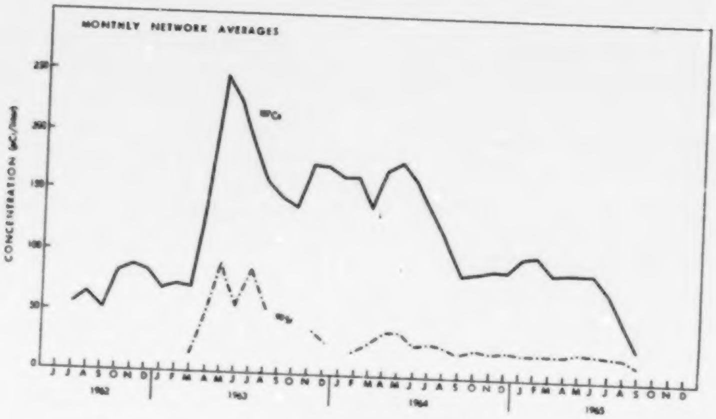

Figure 4. Radionuclide concentrations in Oregon milk network, 1962–September 1965

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
October–December 1964 and Summary 1962–1964	*June 1965*
January–March 1965	*August 1965*
April–June 1965	*December 1965*

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3. Washington Milk Network
July–September 1965

Air Sanitation and Radiation Control Section
State of Washington Department of Health

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. The collection points shown in figure 5 were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. This sampling program provides representation for a large percentage of the State population's milk supply. In addition to the eight milk sampling locations in Washington, milk is sampled from Northwest Idaho (Sandpoint), as this area

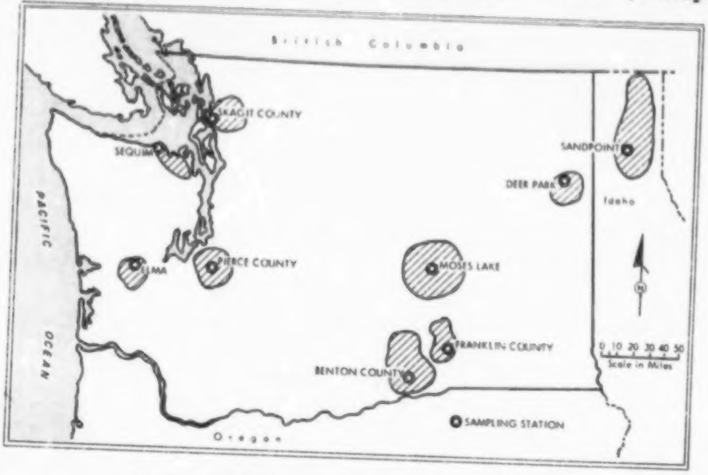
British Columbia
SKAGIT COUNTY
SEQUIM
SANDPOINT
DEER PARK
Idaho
PACIFIC OCEAN
ELMA
PIERCE COUNTY
MOSES LAKE
N
FRANKLIN COUNTY
BENTON COUNTY
0 10 20 30 40 50
Scale in Miles
SAMPLING STATION
Oregon

Figure 5. Washington milkshed production areas

forms a part of the Spokane milkshed. Details of the sampling procedures were presented earlier (*5*).

Selected samples are radiochemically analyzed for strontium-90. Potassium-40, iodine-131, cesium-137, and barium-140 concentrations are determined by gamma-scintillation spectrometry. Details of the analytical procedures were presented earlier (*5*).

Table 3 presents monthly radionuclide concentrations in Washington raw milk for July through September 1965. During this period iodine-131 and barium-140 concentrations remained below minimum detectable levels. Monthly average strontium-90 and cesium-137 concentrations are presented graphically in figure 6, so as to display general trends.

Zinc-65 was observed in Franklin County on two occasions during this period (table 4). This nuclide has periodically appeared in this county as a result of the irrigation of some pasture land with Columbia River water which has been shown to contain this contaminant.

Table 3. Radionuclide concentrations (pCi/liter) in Washington milk, July–September 1965

Sampling locations	Potassium-40			Strontium-90			Cesium-137		
	July	Aug	Sept	July	Aug	Sept	July	Aug	Sept
Benton County	NS	1,184	NS	NS	7	NS	NS	30	NS
Deer Park	1,250	1,214	1,232	15	14	12	53	63	49
Elma	1,365	1,192	1,156	12	15	11	87	75	80
Franklin County	1,326	NS	1,250	6	NS	8	24	NS	28
Moses Lake	1,280	1,261	1,252	21	8	6	45	33	26
Pierce County	1,155	1,367	1,347	17	21	15	136	114	70
Sandpoint	1,303	1,369	1,198	31	30	25	138	160	106
Sequim	1,133	1,324	1,103	11	10	10	49	50	30
Skagit County	1,170	1,151	1,155	8	18	16	82	72	61
Average	1,248	1,258	1,212	15	15	13	77	75	56

NS, no sample collected

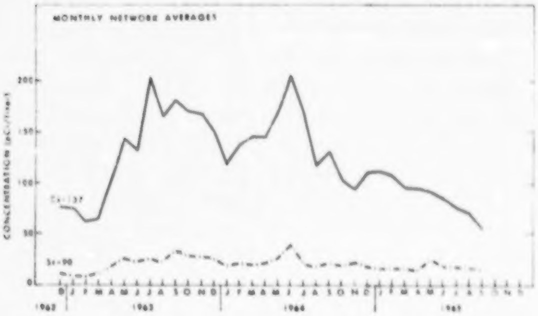

Figure 6. Radionucilde concentrations in Washington milk 1962–September 1965

Table 4. Milk samples in Franklin County, Washington, containing zinc-65

Sampling location	Date (1965)	Zinc-65 (pCi/liter)
Franklin County	July 14	74
Franklin County	September 8	258

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
December 1962–December 1963	*May 1964*
January–June 1964	*February 1965*
July–December 1964	*May 1965*
January–June 1965	*November 1965*

REFERENCES

(*1*) STATE OF CALIFORNIA DEPARTMENT OF PUBLIC HEALTH. California Milk Network, 1960–June 1962. Rad Health Data 4:90–92 (February 1963).

(*2*) HESLEP, J. M., and A. C. CORNISH. California Milk Network and milkshed comparisons, April–June 1963. Rad Health Data 4:596–599 (December 1963).

(*3*) MURTHY, G. K., J. E. COAKLEY, and J. E. CAMPBELL. A method for the elimination of ashing in strontium-90 determinations in milk. J Dairy Sci 43:151–154 (1960).

(*4*) DIVISION OF SANITATION AND ENGINEERING, OREGON STATE BOARD OF HEALTH. Oregon Milk Network, April–June 1965. Rad Health Data 6:683–684 (December 1965).

(*5*) AIR AND RADIATION CONTROL SECTION, STATE OF WASHINGTON DEPARTMENT OF HEALTH. Washington Milk Network, January–June 1965. Rad Health Data 6:619–621 (November 1965).

FOOD AND DIET SURVEILLANCE ACTIVITIES

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuous basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in routine operation and reported periodically include: (1) the Public Health Service's Institutional Total Diet Sampling Network, (2) the Atomic Energy Commission's Tri-City Diet Study, (3) the Food and Drug Administration's Teenage Diet Study, (4) the State of California's Diet Study, and (5) the State of Connecticut's Standard Diet Study. While not based on probability sampling, these networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides.

Other diet programs previously covered in *Radiological Health Data and Reports* are listed below.

Program	Period reported	Last presented
Institutional Total Diet	April–June 1965	February 1966
Tri-City Diet	February–April 1965	December 1965
Teenage Diet	February–November 1964	July 1965
California Diet	November–December 1964	December 1965
Connecticut Standard Diet	March 1963–December 1964	July 1965

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1. Strontium-90 in Tri-City Diets
May–July 1965 [1]

Health and Safety Laboratory
U.S. Atomic Energy Commission

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium-90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these three cities about every 3 months and are analyzed for strontium-90. Fourteen of the diet categories are analyzed on a quarterly basis. Eggs, poultry, fresh fish, shellfish, and meat are purchased quarterly, but analyzed annually. This policy was initiated in 1965 due to the lower concentrations of strontium-90 in these food categories. The contribution of these five diet categories to the total annual intake of strontium-90 over the last 4 years has been approximately 5 percent. Therefore, this figure is used to calculate the contribution of these food categories to the total diet strontium-90 intake. These values are added to the contributions of the other 14 food categories to obtain quarterly estimates of annual strontium-90 intake at the three cities. Consumption figures used are based upon data from the Department of Agriculture (*1*).

Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general.

The consumption data are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

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[1] Data from Fallout Program Quarterly Summary Report, HASL-165 January 1, 1966. Available from the Clearinghouse for Federal Scientific and Technical Information, CFSTI, 5285 Port Royal Road, Springfield, Virginia 22151.

After two samplings at each city, it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses of dietary components were performed for the third time recently, and further confirmed this result (2). Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this material. Details of the sampling system and a discussion of results obtained have been summarized (3).

Results of the May to July 1965 sampling are presented in table 1. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1.

Table 1. Average dietary consumption and strontium-90 intake in Tri-City diet, May–July 1965

Food category	Diet (kg/yr)	Calcium (g/yr)	New York City— May 1965		Chicago— July 1965		San Francisco— June 1965	
			(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)	(pCi/kg)	(pCi/yr)
Bakery products	37	37.0	27.4 ±1.0	1,014	22.2 ±1.2	821	12.4 ±1.0	459
Whole grain products	11	10.0	48.0 ±1.3	528	46.2 ±1.7	508	22.9 ±2.0	252
Fresh vegetables	43	15.0	17.4 ±0.4	748	7.9 ±0.3	340	3.0 ±0.3	129
Root vegetables	17	6.1	11.4 ±0.5	194	4.7 ±0.4	80	3.8 ±0.2	65
Milk	221	234.4	22.6 ±0.4	4,995	9.2 ±0.3	2,033	11.4 ±0.4	2,519
Flour	43	8.6	22.6 ±0.4	972	17.9 ±0.3	770	4.5 ±0.2	194
Macaroni	3	0.7	14.9 ±0.7	45	14.4 ±0.5	43	9.6 ±0.5	29
Rice	3	1.1	2.2 ±0.2	7	3.6 ±0.3	11	3.2 ±0.3	10
Dried beans	3	2.9	35.0 ±1.8	105	18.8 ±1.8	56	12.8 ±0.2	38
Fresh fruit	68	12.6	8.5 ±0.4	578	2.3 ±0.2	156	3.8 ±0.3	258
Potatoes	45	5.8	9.7 ±0.5	436	2.4 ±0.5	108	1.6 ±0.4	72
Canned fruit	26	1.3	3.9 ±0.2	101	4.0 ±0.1	104	2.0 ±0.1	52
Fruit juices	19	1.7	6.7 ±0.4	127	6.8 ±0.3	129	2.9 ±0.2	55
Canned vegetables	20	4.2	25.0 ±0.7	500	11.1 ±0.5	222	3.0 ±0.5	60
Meat, fish, poultry, shellfish, and eggs	99	42.0		[a] 545		[a] 280		[a] 221
Annual intake	—	383.0	—	10,895	—	5,664	—	4,413
pCi strontium-90/g Ca				28.4		14.8		11.5

[a] Estimated as 5 percent of total intake.

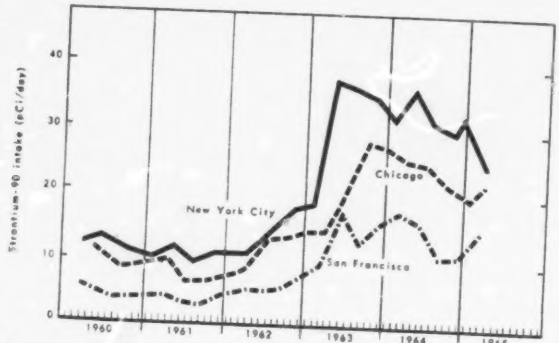

Figure 1. Daily intake of strontium-90 in Tri-City diet 1960–July 1965

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
Sixteenth Sampling (February–April 1964)	*December 1964*
Seventeenth Sampling (May–July 1964)	*March 1965*
Eighteenth Sampling (August–October 1964)	*June 1965*
Nineteenth Sampling (November 1964–January 1965)	*September 1965*

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2. Estimated daily intake of radionuclides in California diets January–April 1965 [1]

Bureau of Radiological Health
California State Department of Public Health

Since January 1964, the Bureau of Radiological Health, California State Department of Public Health, has made estimates of radionuclide levels in the diets of Californians (*4*).

Recognizing that a "standard" or "typical" diet does not exist due to variations in individual tastes, an effort was made to select a diet which was reasonably representative of the food consumed in a given area. This objective was met by utilizing the "house" diet of a hospital in each of the 20 geographic areas of interest.

Hospitals were chosen as the source of diet samples under the hypothesis of their being as "reasonably representative" as any other. General hospitals exist in each of the selected geographic areas and operate with trained dietitians. There is good reason to believe that hospitals utilize foods which are marketed in their respective communities. Also, working relations for entry into hospitals existed through the State Bureau of Nutrition and Hospitals.

Sampling procedure

In general, the sampling procedure is the same at each hospital. Samples are collected once every 2 months at each facility. Each sample represents the edible portion of a regular meal (the standard diet) for a full 7-day week (21 consecutive meals).

After each sample is collected, it is suitably preserved and shipped to the Sanitation and Radiation Laboratory. Accompanying each sample is a record prepared by the dietitians indicating the types and quantities of food included.

Analytical procedures

After weighing at the Laboratory, each sample is homogenized, dried, and ashed prior to stable calcium, potassium, strontium, and sodium determinations being made.

The radiochemical analyses are based upon three basic procedures: chemical separations of strontium–89 and strontium–90; analysis of radium–226; and gamma spectrometry of the entire wet sample.

Data and discussion

The resultant estimates of daily intake of radionuclides in the California diets are given in tables 2 and 3 for January through April

Table 2. Estimated daily intake of radionuclides in California diets January–February, 1965 [a]

City	Kg/capita per day [b]	pCi/capita • day					Grams/capita • day			
		^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{141}Ce ^{144}Ce	K [c]	Na	Ca	Stable Sr
Bakersfield	1.5	7	0.2	32	0	0	1.9	2.3	0.7	0.001
Berkeley	2.9	22	0.6	85	0	0	4.4	5.9	1.3	0.001
Bishop	1.8	15	0.2	96	11	0	2.3	2.9	0.6	0.003
Brawley	2.3	19	1.3	57	23	0	3.2	3.9	1.3	0.001
Crescent City	2.2	46	0.6	150	11	42	2.7	4.0	0.9	0.001
Eureka	2.1	22	0.6	87	0	0	2.5	2.5	1.2	0.001
Fresno	2.5	14	1.0	8	0	5	3.5	5.3	0.9	0
Los Angeles	1.3	6	0.2	46	0	15	1.9	2.4	0.7	0.001
Needles	2.3	10	0.7	66	0	0	2.5	4.0	1.0	0.001
Quincy	1.3	9	0.3	49	0	0	2.1	2.6	0.3	0.001
Redding	2.1	11	0.3	72	0	3	3.0	5.0	0.7	0.001
Sacramento	2.7	12	0.9	73	10	0	2.3	4.5	0.9	0.001
Salinas	2.4	10	0.8	60	2	0	2.9	4.7	0.8	0.001
San Bernardino	2.2	13	0.3	60	6	0	2.8	4.0	1.2	0.001
San Diego	2.2	8	0.9	54	0	0	2.7	3.3	0.9	0.001
San Luis Obispo [d]										
Santa Barbara	2.4	17	0.9	75	2	0	3.2	4.4	1.1	0.003
Santa Rosa	2.4	13	0.6	114	2	0	3.0	3.3	1.2	0
Susanville	2.2	9	0.2	75	0	24	2.3	6.0	0.8	0.001
Ukiah	2.1	24	1.0	47	0	0	2.8	2.8	2.0	0

[a] Based on analyses of Hospital Standard Diets located in listed cities. Strontium-89 and manganese-54 not detectable.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
[d] Sample lost or unsatisfactory.

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[1] This work was summarized under the supervision of Amasa C. Cornish, senior health physicist, Jack L. Brown, associate health physicist, and George Barr, radiological health specialist, Bureau of Radiological Health, California State Department of Public Health.

Table 3. Estimated daily intake of radionuclides in California diets, March–April 1965 [a]

City	Kg/capita per day [b]	pCi/capita • day						Grams/capita • day			
		^{90}Sr	^{226}Ra	^{137}Cs	^{95}Zr	^{54}Mn	^{141}Ce ^{144}Ce	K [c]	Na	Ca	Stable Sr
Bakersfield	2.2	12	0.5	58	10	0	0	2.7	3.3	2.2	0.001
Berkeley	2.4	12	0.3	54	0	0	0	2.4	4.2	0.7	0.005
Bishop	1.6	10	0.4	65	9	0.3	9.0	1.8	2.7	0.5	0
Brawley	2.8	12	1.0	58	15	0	0	3.5	4.5	1.1	0.001
Crescent City	2.3	28	0.2	121	14	0	0	2.5	4.6	2.1	0.001
Eureka	2.4	29	0.2	122	39	0	0	3.0	3.0	1.2	0.007
Fresno	2.3	11	0.7	63	13	0.1	0.4	2.3	4.0	0.8	0.002
Los Angeles	2.0	6	0.1	60	2	0	0	1.8	2.4	0.5	0.005
Needles	2.4	13	0.2	66	5	0	0	2.2	3.2	2.1	0.001
Quincy	2.0	16	0.2	90	10	3.3	0	2.8	3.6	2.1	0.001
Redding	2.1	25	1.1	65	9	0	3.4	NA	NA	1.0	0.002
Sacramento	2.9	2	0.6	83	0	4.2	11.0	2.9	6.0	1.3	0
Salinas	2.5	13	0.2	70	5	0.3	5.8	2.7	5.1	2.0	0.001
San Bernardino	2.1	9	0.6	47	8	1.6	5.8	2.4	3.5	1.0	0.001
San Diego	2.0	12	0.4	58	2	0	0	2.9	3.1	2.0	0.005
San Luis Obispo	1.4	8	0.2	43	0	0	0	1.8	3.0	1.0	0.001
Santa Barbara	1.6	14	0.6	60	1	0	0.6	2.2	3.0	1.0	0.001
Santa Rosa	2.5	25	0.6	94	5	0	2.9	2.8	3.1	1.3	0
Susanville	2.1	16	0.4	104	6	0	0	2.6	4.3	2.0	0.003
Ukiah	2.4	36	0.5	80	14	0	1	3.3	4.0	1.8	NA

[a] Based on analysis of Hospital Standard Diets located in listed cities. Strontium-89 not detectable.
[b] Kilograms of food per person per day in this diet.
[c] Natural potassium contains 0.0119 percent of radioactive potassium-40.
NA, no analysis

1965. Average strontium-90 intake in the California diet varied from 2 to 46 pCi per capita per day. Cesium-137 intakes varied from 8 to 150 pCi per capita per day. Radium-226 intakes varied from 0.3 to 1.3 pCi per capita per day. The observed intakes of strontium-90, cesium-137, and radium-226 in California diets were of such a magnitude that no actions were indicated based upon health implications.

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Section II. Water

The Public Health Service (and as of January 1966, the Federal Water Pollution Control Administration) and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and/or treated (drinking) water. Most of these programs include determinations of gross alpha and gross beta radioactivity and/or specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These Standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively, without considering other sources of radioactivity. Limits may be higher if total intake of radioactivity from all sources indicates that such intakes are within the limits recommended by FRC for control action. In the known absence of strontium-90 and alpha emitters, the limit is 1,000 pCi/liter gross beta activity.[1] Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. State programs recently covered in Radiological Health Data & Reports are listed below.

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha emitters and strontium-90, respectively.

Program	Period reported	Last presented
Florida Water Sampling Program	1964	November 1965
Kentucky Water Sampling Program	May 1963–June 1964	March 1965
Minnesota Surface Water Sampling Program	January–June 1965	February 1966
New York Surface Water Sampling Program	January–June 1965	January 1966
North Carolina Water Sampling Program	January–December 1964	November 1965
Washington Surface Water Sampling Program	July 1963–June 1964	February 1965

REFERENCES

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(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

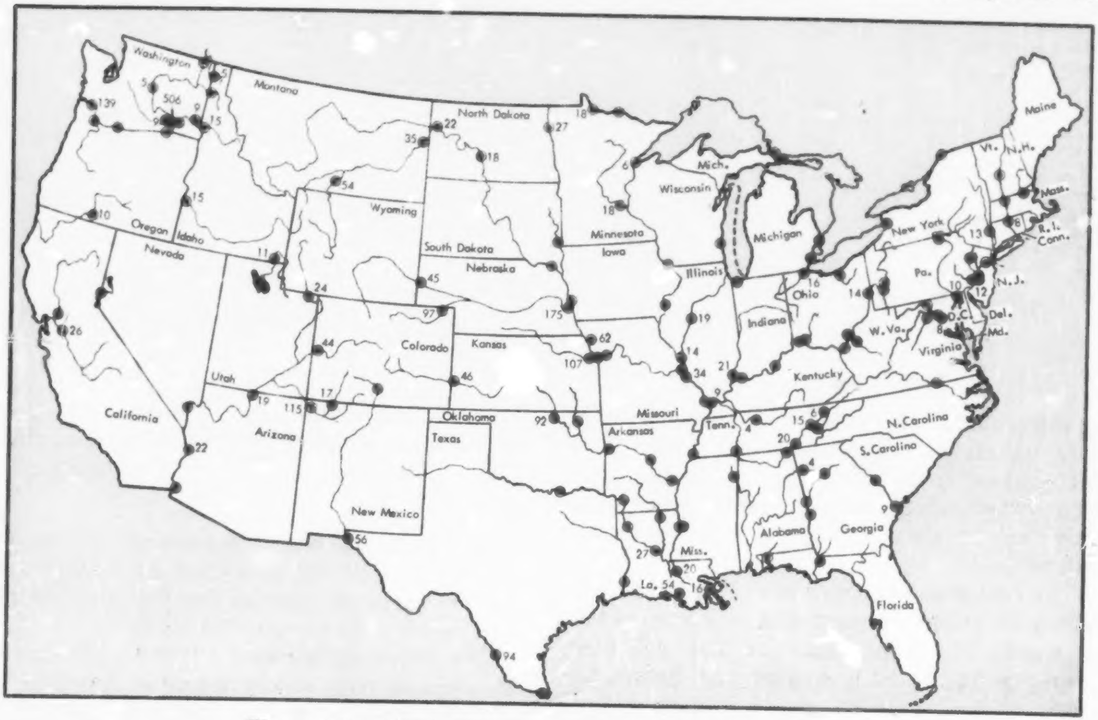
GROSS RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, SEPTEMBER 1965

Basic Data Branch Federal Water Pollution Control Administration

The monitoring of levels of radioactivity in surface waters of the United States began in 1957 as a part of the Public Health Service Water Pollution Surveillance System. Responsibility for this activity was transferred to the newly created Federal Water Pollution Control Administration on December 31, 1965. Table 1 presents the current preliminary results of the alpha and beta analysis. The radioactivity associated with dissolved solids provides a rough indication of the levels which would occur in treated water, since nearly all suspended matter is removed by treatment processes. Strontium-90 results are reported quarterly. The stations on each river are arranged in the table according to their distance from the headwaters. Figure 1 geographically presents the average total beta activity in suspended-plus-dissolved solids in raw water collected at each station. A description of the sampling and analytic procedures was published in the December 1965 *Radiological Health Data.*

Complete data and exact sampling locations are published in annual compilations (*1–6*) or are available on request.

Comments on data are being made when the alpha radioactivity is 15 pCi/liter or greater or when the beta radioactivity is 150 pCi/liter or greater. Changes toward or from these levels are discussed in terms of significant changes in radioactivity per unit weight of solids. No discussion of gross radioactivity per gram of dissolved or suspended solids for all stations of the Water Pollution Surveillance System will


Washington
Montana
North Dakota
Maine
Vt.
N.H.
Mass.
R.I.
Conn.
Mich.
Wisconsin
Minnesota
Michigan
New York
Wyoming
South Dakota
Nebraska
Iowa
Illinois
Oregon
Idaho
Nevada
Ohio
Pa.
N.J.
Del.
Md.
D.C.
Indiana
W.Va.
Virginia
Colorado
Kansas
Kentucky
Utah
California
Arizona
Oklahoma
Missouri
Arkansas
Tenn.
N.Carolina
S.Carolina
Texas
New Mexico
Alabama
Georgia
Miss.
La.
Florida
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16
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94

Figure 1. Sampling locations and associated total beta activity (pCi/liter) in surface waters, September 1965

Table 1. Radioactivity in raw surface waters, September 1965

(average concentrations in pCi/liter)

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Animas River:						
Cedar Hill, N. Mex	11	6	17	3	1	4
Arkansas River:						
Coolidge, Kans	13	33	46	4	17	21
Ponca City, Okla	73	19	92	23	4	27
Atchafalaya River:						
Morgan City, La	41	13	54	16	2	18
Bear River:						
Preston, Idaho	0	11	11	0	1	1
Big Horn River:						
Hardin, Mont	33	21	54	11	7	18
Chena River:						
Fairbanks, Alaska	12	3	15	4	1	5
Clearwater River:						
Lewiston, Idaho	11	4	15	4	1	5
Clinch River:						
Clinton, Tenn	1	5	6	0	0	0
Kingston, Tenn	3	12	15	0	0	0
Colorado River:						
Loma, Colo	22	22	44	6	5	11
Page, Ariz	4	15	19	1	2	3
Parker Dam, Calif-Ariz	1	21	22	0	7	7
Columbia River:						
Wenatchee, Wash	0	5	5	0	0	0
Pasco, Wash	63	443	506	0	1	1
Clatskanie, Ore	13	126	139	0	1	1
Connecticut River:						
Enfield Dam, Conn	2	6	8	0	0	0
Coosa River:						
Rome, Ga	1	3	4	0	0	0
Cumberland River:						
Cheatham Lock, Tenn	0	4	4	0	0	0
Delaware River:						
Philadelphia, Pa	2	10	12	0	0	0
Great Lakes:						
Duluth, Minn	2	4	6	0	0	0
Green River:						
Dutch John, Utah	1	23	24	0	4	4
Hudson River:						
Poughkeepsie, N.Y	2	11	13	0	0	0
Illinois River:						
Peoria, Ill	6	13	19	2	2	4
Grafton, Ill	2	12	14	1	1	2
Kansas River:						
De Soto, Kans	78	29	107	21	5	26
Klamath River:						
Keno, Ore	2	8	10	0	0	0
Maumee River:						
Toledo, Ohio	1	15	16	0	2	2
Mississippi River:						
St. Paul, Minn	2	16	18	0	1	1
E. St. Louis, Ill	18	16	34	4	1	5
New Roads, La	6	14	20	2	1	3
New Orleans, La	2	14	16	1	2	3
Missouri River:						
Williston, N. Dak	5	17	22	1	4	5
Bismarck, N. Dak	2	16	18	<1	3	3
St. Joseph, Mo	37	25	62	7	4	11
North Platte River:						
Henry, Nebr	3	42	45	<1	28	28
Ohio River:						
Toronto, Ohio	1	13	14	0	1	1
Cairo, Ill	1	8	9	0	0	0
Pend Oreille River:						
Albeni Falls Dam, Idaho	<1	5	5	0	1	1
Platte River:						
Plattsmouth, Nebr	154	21	175	60	3	63
Potomac River:						
Washington, D.C	1	7	8	0	0	0
Rainy River:						
Baudette, Minn	2	16	18	0	0	0
Red River, North:						
Grand Forks, N. Dak	2	25	27	0	3	3
Red River, South:						
Alexandria, La	8	19	27	3	4	7
Rio Grande:						
El Paso, Tex	41	15	56	12	4	16
Laredo, Tex	78	16	94	27	5	32
San Joaquin River:						
Vernalis, Calif	3	23	26	0	14	14
San Juan River:						
Shiprock, N. Mex	102	13	115	32	3	35
Savannah River:						
Port Wentworth, Ga	3	6	9	<1	0	<1
Snake River:						
Payette, Idaho	2	13	15	0	5	5
Wawawai, Wash	0	9	9	0	0	0
South Platte River:						
Julesburg, Colo	38	59	97	14	45	59
Susquehanna River:						
Conowingo, Md	1	9	10	0	0	0
Tennessee River:						
Chattanooga, Tenn	1	19	20	0	1	1
Wabash River:						
New Harmony, Ind	11	10	21	4	1	5
Yakima River:						
Richland, Wash	1	8	9	0	1	1
Yellowstone River:						
Sidney, Mont	18	17	35	7	5	12
Maximum	154	443	506	60	45	63
Minimum	0	3	4	0	0	0

be attempted at this time. Comments are made only on monthly average values. Occasional high values from single weekly samples may be absorbed into a relatively low average. When these values are significantly high, comment will be made.

The following stations showed alpha or beta values on either suspended or dissolved solids in excess of 15 pCi/liter or 150 pCi/liter, respectively, for both August and September 1965:

South Platte River:	Julesburg, Colorado
North Platte River:	Henry, Nebraska
Atchafalaya River:	Morgan City, Louisiana
Columbia River:	Pasco, Washington

These stations showed reasonable values for alpha radioactivity per gram of dissolved or suspended solids (except for Pasco, Washington, which shows negligible alpha).

The following stations showed a decline to an alpha activity concentration of less than 15 pCi/liter or to somewhat higher values (Shiprock, New Mexico) than in the month of

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August 1965:

Arkansas River: Coolidge, Kansas (alpha suspended)
San Juan River: Shiprock, New Mexico

The following stations showed increases of alpha radioactivity on dissolved or suspended solids from less than 15 pCi/liter in August to greater than this value for September 1965:

Arkansas River: Coolidge, Kansas (alpha suspended)
Arkansas River: Ponca City, Oklahoma
Kansas River: DeSoto, Kansas
Platte River: Plattsmouth, Nebraska
Rio Grande: Laredo, Texas

At Morgan City, Louisiana, a single weekly sample high in suspended solids raised the average for the month on alpha radioactivity to a value just over 15 pCi/liter. Shiprock, New Mexico, declined in alpha radioactivity to its normal level, which usually exceeds 15 pCi/liter but only by small amounts. The beta radioactivity on dissolved solids at Pasco, Washington, approximately doubled over the previous month.

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(3) *Ibid.*, 1960 Edition.
(4) *Ibid.*, 1961 Edition.
(5) *Ibid.*, 1962 Edition.
(6) DIVISION OF WATER SUPPLY AND POLLUTION CONTROL, PUBLIC HEALTH SERVICE. Water pollution surveillance system, annual compilation of data. PHS Publication No. 663 (Revised) 1963 Edition. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

RADIOACTIVITY IN CALIFORNIA WATERS JANUARY–JUNE 1965[1]

Bureau of Radiological Health, State of California Department of Public Health

Gross beta activity in California domestic waters is monitored by the State of California's Bureau of Radiological Health. The importance of this program in the State's environmental surveillance activities stems from the fact that most of California's domestic water supplies are of surface origin.

Radioactivity in such water supplies consists of the natural radioactivity in surface streams, radioactivity added by the discharge of sewage or by industrial waste effluents, and radioactivity from fallout, particularly fallout into open terminal or distribution reservoirs. Present efforts consist of sampling raw and treated surface waters and well waters. It should be noted that except for large metropolitan water supplies, raw water sampling is being phased out, and treated water sampling being substituted or continued. This procedural change is predicated upon sampling water at the point of consumption.

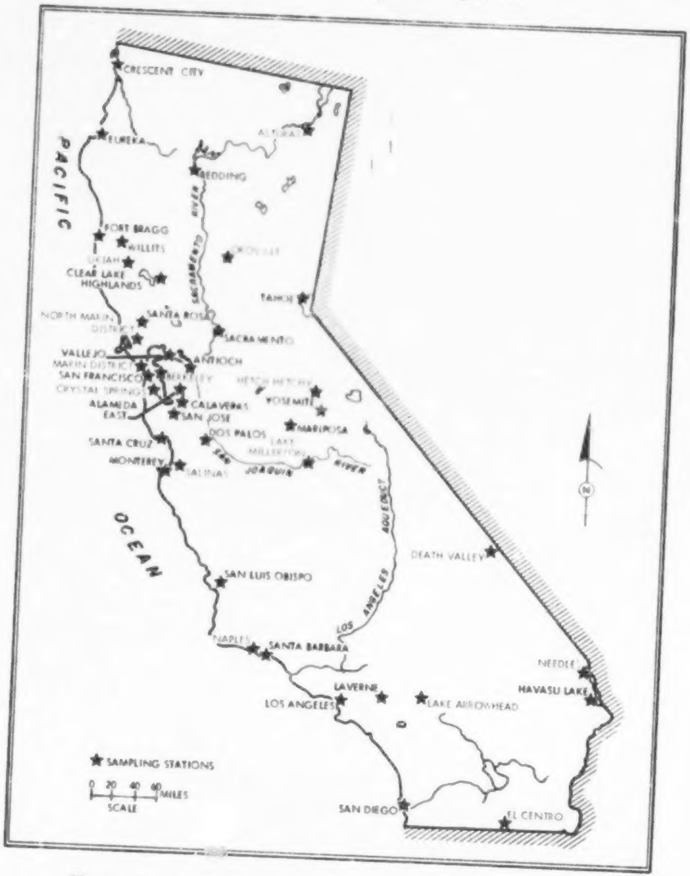
CRESCENT CITY
ALTURAS
EUREKA
PACIFIC
REDDING
SACRAMENTO RIVER
FORT BRAGG
WILLITS
UKIAH
OROVILLE
CLEAR LAKE HIGHLANDS
TAHOE
NORTH MARIN DISTRICT
SANTA ROSA
SACRAMENTO
VALLEJO
MARIN DISTRICT
ANTIOCH
SAN FRANCISCO
BERKELEY
HETCH HETCHY
CRYSTAL SPRINGS
YOSEMITE
ALAMEDA EAST
CALAVERAS
SAN JOSE
MARIPOSA
DOS PALOS
LAKE MILLERTON
SANTA CRUZ
MONTEREY
SALINAS
SAN JOAQUIN RIVER
N
OCEAN
LOS ANGELES AQUEDUCT
DEATH VALLEY
SAN LUIS OBISPO
NAPLES
SANTA BARBARA
NEEDLES
HAVASU LAKE
LAVERNE
LOS ANGELES
LAKE ARROWHEAD
SAMPLING STATIONS
0 20 40 60 MILES
SCALE
SAN DIEGO
EL CENTRO

Figure 1. California surface water sampling stations

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[1] Data from July and October 1965 issues of Radiological Health News, California Department of Public Health, Bureau of Radiological Health, 2151 Berkeley Way, Berkeley 4, California.

Table 1. Gross beta activity in California domestic waters (pCi/liter), January–June 1965

Sampling stations	Quality	January	February	March	April	May	June
Alturas	Well	[a]13	NS	ND	[a]10	[a]6	ND
Antioch	Treated	[a]6	ND	ND	[a]18	ND	ND
Lake Arrowhead	Treated	NS	[a]4	NS	[a]5	[a]14	[a]6
Berkeley	Treated	[a]6	[a]13	[a]4	[a]10	NS	ND
Clearlake Highlands	Treated	[a]6	ND	[a]10	[a]9	ND	ND
Crescent City	Raw	NS	NS	[a]1	[a]6	ND	ND
Death Valley	Treated	[a]12	2	NS	ND	[a]6	NS
Dos Palos	Treated	[a]22	[a]12	ND	[a]16	[a]17	[a]5
El Centro	Treated	[a]20	[a]9	[a]3	ND	ND	[a]16
Eureka	Raw	[a]53	[a]15	ND	ND	ND	NS
	Treated	ND	[a]2	ND	ND	ND	ND
Fort Bragg	Treated	[a]7	[a]4	ND	ND	NS	NS
Los Angeles Laboratory	Treated	[a]11	ND	[a]3	ND	ND	ND
Marin Municipal Water District	Treated	ND	[a]1	[a]4	[a]2	ND	[a]9
Mariposa	Treated	[a]11	[a]6	ND	[a]3	ND	[a]2
Metropolitan Water District of Southern California:							
Lake Havasu	Treated	ND	NS	NS	[a]3	NS	[a]23
Weymouth Plant	Treated	NS	[a]18	[a]18	[a]12	40	[a]16
Lake Millerton	Treated	[a]11	[a]3	[a]20	NS	ND	[a]5
Monterey	Treated	[a]7	ND	ND	[a]14	[a]12	[a]4
Naples	Treated	[a]5	NS	NS	ND	[a]4	[a]10
Needles	Raw	ND	NS	NS	NS	NS	NS
North Marin Water District	Treated	[a]13	ND	[a]5	[a]17	[a]4	ND
	Raw	[a]14	[a]2	ND	[a]12	16	[a]11
	Sludge [b]	[a]91	[a]54	[a]15	[a]99	54	[a]10
Oroville:							
California Water Service	Treated	[a]7	[a]13	ND	[a]4	[a]3	[a]7
Wyandotte Irrigation District	Treated	[a]11	[a]12	[a]8	[a]9	NS	ND
Redding	Treated	[a]10	[a]2	ND	NS	NS	NS
Sacramento	Raw	ND	[a]3	[a]1	[a]9	[a]3	NS
Salinas	Well	NS	NS	NS	ND	[a]5	NS
San Diego	Raw	NS	NS	[a]13	ND	[a]28	[a]2
	Treated	ND	[a]19	[a]14	[a]23	[a]8	ND
San Francisco:							
Water Department	Treated	[a]11	[a]2	[a]7	ND	[a]12	ND
Alameda, East	Treated	[a]5	[a]19	[a]8	[a]10	ND	[a]3
Brightside Weir	Raw	ND	ND	[a]19	[a]2	ND	[a]3
Calaveras Reservoir	Raw	[a]8	[a]2	[a]9	[a]1	[a]4	[a]4
Crystal Springs	Treated	ND	[a]10	[a]24	[a]9	[a]2	[a]4
Hetch Hetchy	Raw	NS	[a]15	[a]13	[a]10	[a]5	[a]4
San Jose	Raw	[a]5	[a]1	[a]9	ND	NS	NS
San Luis Obispo	Treated	[a]16	NS	NS	[a]15	NS	ND
Santa Barbara	Treated	ND	37	[a]5	[a]7	19	[a]2
Santa Cruz	Coastal	ND	NS	NS	NS	[a]12	NS
	Raw	[a]5	[a]3	NS	NS	NS	NS
	Treated	ND	NS	[a]5	[a]10	ND	[a]9
Santa Rosa	Raw	ND	NS	NS	NS	NS	NS
	Treated	ND	ND	ND	ND	[a]2	ND
Tahoe City	Raw	NS	14	ND	NS	NS	NS
	Treated	NS	NS	NS	[a]8	NS	NS
Ukiah	Treated	NS	ND	NS	NS	ND	[a]9
Vallejo:							
Fleming Hill	Raw	[a]20	[a]15	[a]5	[a]14	[a]12	[a]3
	Treated	[a]7	ND	ND	[a]19	[a]8	[a]8
Swanzy Reservoir	Treated	[a]7	[a]4	[a]17	[a]6	ND	ND
Willits	Treated	[a]9	[a]7	[a]3	[a]16	[a]11	[a]2
Yosemite	Treated	[a]18	ND	[a]4	[a]22	ND	[a]16
Maximum (not including sludge)		53	37	24	23	40	23
Minimum		0	0	0	0	0	0

[a] When the counting rate of the sample is not equal to at least twice the 0.95 error, the value reported is the best estimate, but is not statistically significant.

[b] Sludge reported in pCi/g (dry weight).

NS, no sample collected.

ND, no detectable activity.

Most of the supplies sampled have as a source, raw surface waters (figure 1), although a few wells, along with some water supplies that use infiltration galleries, are also sampled.

Monitoring of domestic water supplies is on a continuing basis, since it has not been possible to forecast levels of radioactivity in these supplies based upon levels in rain, snow, or surface streams. Under the present sampling schedule, monthly 500-ml samples are collected and the total solids analyzed for alpha and beta radioactivity. In addition, 3-liter samples are collected monthly for approximately 6 months and composited for specific radionuclide analysis on a biannual basis.

Analytical procedures

Radionuclide analyses of water are carried out in the State's Sanitation and Radiation Laboratory. Measurements of alpha and alpha-plus-beta activities are made with a low-background windowless gas-flow proportional counter. Counting methods used follow those recommended by the U.S. Public Health Service (*1*).

Individual samples are evaporated to dryness and the residue ashed at 450° C. The ashed sample is dissolved and transferred to an aluminum planchet for beta counting. Gamma-emitting radionuclides are determined biannually on the composite samples.

Discussion

Table 1 shows the monthly average beta activity in the suspended-plus-dissolved solids in surface water supplies in California from January through June 1965. Following treatment, these waters are used for industrial and domestic purposes. Because alpha activity in water has in general been undetectable or very slight, alpha activity analyses are not presented. No increase in the radioactivity level of surface water has been observed, while fallout levels continue to decline slowly.

REFERENCE

(*1*) DIVISION OF RADIOLOGICAL HEALTH. Radionuclide analyses of environmental samples, R 59-6. Radiological Health Research Activities, Robert A. Taft Sanitary Engineering Center, Cincinnati, Ohio 45226 (November 16, 1959).

Previous coverage in *Radiological Health Data:*

Period	Issue
1961–June 1962	*April 1963*
July–December 1962	*September 1963*
January–June 1963	*March 1964*
July–December 1963	*September 1964*
January–June 1964	*March 1965*
July–December 1964	*September 1965*

Section III. Air and Deposition

RADIOACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product activity. To date, this surveillance has been confined chiefly to gross beta analysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used for determining when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson (*1*) in 1962.

Other air and deposition networks previously covered in *Radiological Health Data and Reports* follow:

Network	Period reported	Last presented
National Air Sampling Network	July–September 1965	January 1966
HASL Fallout Network	April–December 1964	September 1965

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1. Radiation Surveillance Network
November 1965

Division of Radiological Health
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN), which regularly gathers samples from 74 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

Daily samples of airborne particulates and precipitation are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, for laboratory analysis. The alerting function of the network is provided by routine field estimates of the gross beta activity made by the station operators prior to submission of the samples. When high air levels are reported, appropriate officials are promptly notified. Compilation of field estimates and laboratory confirmations are reported elsewhere on a monthly basis (*2*). A detailed description of the sampling and analysis procedures was presented in the December 1965 issue of *Radiological Health Data.*

Table 1 presents the monthly average gross beta activity in surface air and deposition by precipitation during November 1965. Time profiles of gross beta in air dating back to 1958 for eight RSN stations are shown in figure 2. Gamma spectroscopy analysis was performed on 291 air samples. Traces of longer-lived fresh fission products were identified on most of these.

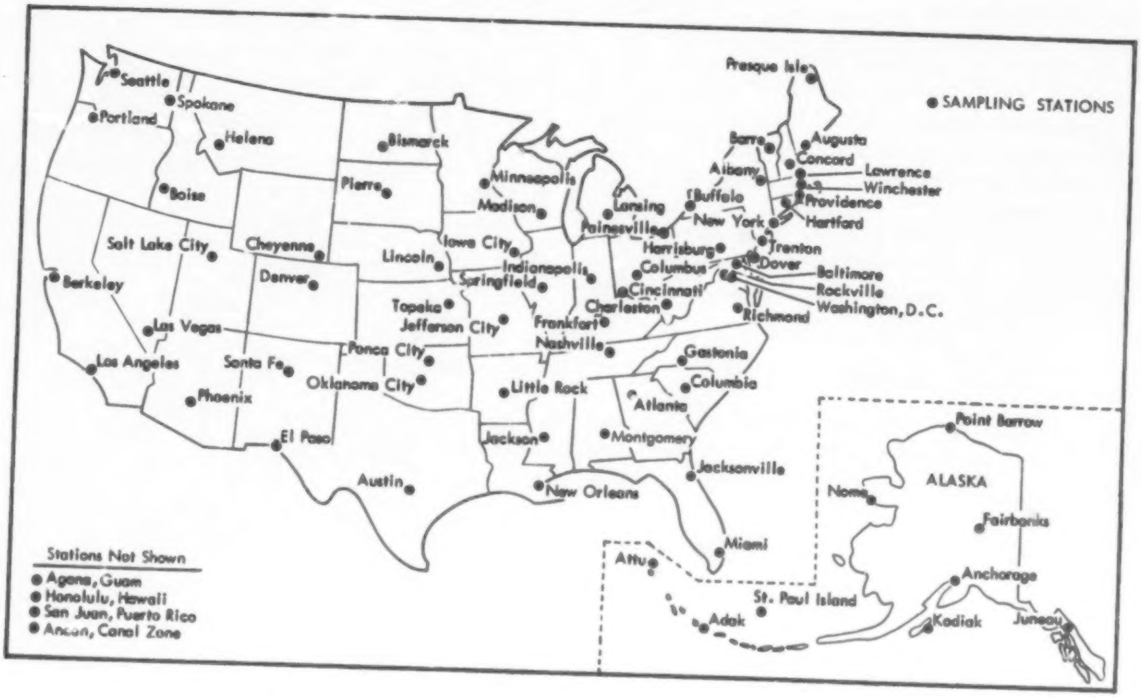
● SAMPLING STATIONS
Seattle
Spokane
Portland
Helena
Boise
Salt Lake City
Berkeley
Las Vegas
Los Angeles
Phoenix
Santa Fe
El Paso
Cheyenne
Denver
Bismarck
Pierre
Lincoln
Topeka
Jefferson City
Ponca City
Oklahoma City
Austin
Minneapolis
Madison
Iowa City
Indianapolis
Springfield
Little Rock
Jackson
New Orleans
Montgomery
Atlanta
Nashville
Frankfort
Lansing
Painesville
Columbus
Cincinnati
Charleston
Gastonia
Columbia
Jacksonville
Miami
Presque Isle
Barre
Augusta
Concord
Albany
Buffalo
Lawrence
Winchester
Providence
Hartford
New York
Trenton
Harrisburg
Dover
Baltimore
Rockville
Washington, D.C.
Richmond
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Kodiak
Juneau
Attu
Adak
St. Paul Island
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

Figure 1. Radiation Surveillance Network sampling stations

Table 1. Gross beta activity in surface air and precipitation, October 1965

Station location		Air surveillance						Precipitation	
		Number of samples		Gross beta activity, pCi/m³			Last profile in *RHD & R*	Total depth (mm)	Total deposition (nCi/m²)[a]
		Air	Pptn	Maximum	Minimum	Average[a]			
Ala:	Montgomery	30	3	0.16	<0.10	<0.10	Feb 66	41	<8
Alaska:	Adak	30		<0.10	<0.13	<0.10	Sep 65	(c)	
	Anchorage	16	2	0.11	<0.10	<0.10	Mar 66	7	<1
	Attu Island	13		0.13	<0.10	<0.10	Oct 65	(c)	
	Fairbanks	8	4	<0.10	<0.10	<0.10	Jun 65	12	<2
	Juneau	22	9	<0.10	<0.10	<0.10	Jul 65	88	<18
	Kodiak	12		<0.10	<0.10	<0.10	Aug 65	(c)	
	Nome	9		<0.10	<0.10	<0.10	Dec 65	(c)	
	Point Barrow	28		<0.10	<0.10	<0.10	Nov 65	(c)	
	St. Paul Island	29		<0.10	<0.10	<0.10	Jan 66	(c)	
Ariz:	Phoenix	28		0.23	<0.10	<0.12	Jul 65	(c)	
Ark:	Little Rock	25	4	0.11	<0.10	<0.10	Mar 66	44	<9
Calif:	Berkeley	19	10	0.13	<0.10	<0.10	Aug 65	139	<28
	Los Angeles	20	8	0.18	<0.10	<0.11	Dec 65	264	<53
C. Z:	Ancon	11		<0.10	<0.10	<0.10	Aug 65	(c)	
Colo:	Denver	28	1	0.15	<0.10	<0.11	Aug 65	8	<2
Conn:	Hartford	29	10	<0.10	<0.10	<0.10	Jul 65	50	<10
Del:	Dover	20		<0.10	<0.10	<0.10	Feb 66	(c)	
D. C:	Washington	28	5	<0.10	<0.10	<0.10	Nov 65	10	<2
Fla:	Jacksonville	29	5	0.14	<0.10	<0.10	Mar 66	56	<11
	Miami	30	5	0.14	<0.10	<0.10	Jul 65	67	<13
Ga:	Atlanta	(b)					Jan 66	(c)	
Guam:	Agana	29		<0.10	<0.10	<0.10	Feb 66	(c)	
Hawaii:	Honolulu	30	6	<0.10	<0.10	<0.10	Oct 65	237	<47
Idaho:	Boise	20	7	<0.10	<0.10	<0.10	Oct 65	30	<6
Ill:	Springfield	30		0.13	<0.10	<0.10	Nov 65	(c)	
Ind:	Indianapolis	30	5	0.15	<0.10	<0.10	Jan 66	32	<7
Iowa:	Iowa City	28	2	<0.10	<0.10	<0.10	Aug 65	36	<7
Kans:	Topeka	29	1	<0.10	<0.10	<0.10	Mar 66	3	<1
Ky:	Frankfort	24	4	0.14	<0.10	<0.10	Nov 65	19	<4
La:	New Orleans	30	4	0.11	<0.10	<0.10	Nov 65	44	<9
Maine:	Augusta	30	14	<0.10	<0.10	<0.10	Dec 65	142	<29
	Presque Isle	21	1	<0.10	<0.10	<0.10	Aug 65	17	<3
Md:	Baltimore	20	2	<0.10	<0.10	<0.10	Jul 65	14	<3
	Rockville Lab	12		0.11	<0.10	<0.10	Oct 65	(c)	
Mass:	Lawrence	30	9	<0.10	<0.10	<0.10	Feb 66	56	<11
	Winchester	27	12	<0.10	<0.10	<0.10	Sep 65	69	<14
Mich:	Lansing	30	8	<0.10	<0.10	<0.10	Oct 65	41	<8
Minn:	Minneapolis	20	5	<0.10	<0.10	<0.10	Feb 66	58	<12
Miss:	Jackson	28	2	<0.10	<0.10	<0.10	Dec 65	30	<6
Mo:	Jefferson City	30	3	<0.10	<0.10	<0.10	Jan 66	18	<4
Mont:	Helena	27	6	<0.10	<0.10	<0.10	Sep 65	16	<3
Nebr:	Lincoln	18		0.23	<0.10	<0.11	Jan 66	(c)	
Nev:	Las Vegas	25	2	0.17	<0.10	<0.11	Jun 65	22	<4
N. H:	Concord	19		<0.10	<0.10	<0.10	Nov 65	(c)	
N. J:	Trenton	30	3	<0.10	<0.10	<0.10	Dec 65	7	<1
N. Mex:	Santa Fe	26	3	0.17	<0.10	<0.10	Sep 65	14	<3
N. Y:	Albany	15	8	<0.10	<0.10	<0.10	Jan 66	47	<9
	Buffalo	28		<0.10	<0.10	<0.10	Aug 65	(c)	
	New York	29		<0.10	<0.10	<0.10	Sep 65	(c)	
N. C:	Gastonia	30	5	0.11	<0.10	<0.10	Aug 65	67	<13
N. Dak:	Bismarck	27	2	0.13	<0.10	<0.10	Nov 65	4	<1
Ohio:	Cincinnati	16		<0.10	<0.10	<0.10	Feb 66	(c)	
	Columbus	29	7	0.16	<0.10	<0.10	Dec 65	30	<6
	Painesville	29	10	0.11	<0.10	<0.10	Jul 65	96	<19
Okla:	Oklahoma City	30		0.12	<0.10	<0.10	Oct 65	(c)	
	Ponca City	29		<0.10	<0.10	<0.10	Jul 65	(c)	
Ore:	Portland	29	17	0.17	<0.10	<0.11	Jan 66	93	<19
Pa:	Harrisburg	28	4	<0.10	<0.10	<0.10	Jan 66	31	<6
P. R:	San Juan	27	3	0.25	<0.10	<0.11	Dec 65	59	<12
R. I:	Providence	29	8	<0.10	<0.10	<0.10	Oct 65	56	<11
S. C:	Columbia	29	5	0.11	<0.10	<0.10	Sep 65	30	<6
S. Dak:	Pierre	30		0.15	<0.10	<0.10	Jul 65	(c)	
Tenn:	Nashville	30	7	<0.10	<0.10	<0.10	Oct 65	51	<10
Tex:	Austin	30	4	0.15	<0.10	<0.10	Feb 66	86	<17
	El Paso	28		0.20	<0.10	<0.11	Nov 65	(c)	
Utah:	Salt Lake City	30	10	0.15	<0.10	<0.11	Dec 65	36	<7
Vt:	Barre	28	15	<0.10	<0.10	<0.10	Mar 66	98	<20
Va:	Richmond	29	3	0.11	<0.10	<0.10	Mar 66	12	<2
Wash:	Seattle	28	18	<0.10	<0.10	<0.10	Mar 66	99	<20
	Spokane	30	5	<0.10	<0.10	<0.10	Feb 66	35	<7
W. Va:	Charleston	27	3	0.12	<0.10	<0.10	Sep 65	17	<4
Wis:	Madison	30	6	<0.10	<0.10	<0.10	Mar 66	43	<9
Wyo:	Cheyenne	29		0.16	<0.10	<0.11	Jun 65	(c)	
Network summary		1,860	305	0.25	<0.10	<0.10		52	<11

[a] The monthly average is calculated by weighting the individual samples with the length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.

[b] Indicates no report received.

[c] Indicates no precipitation sample collected.

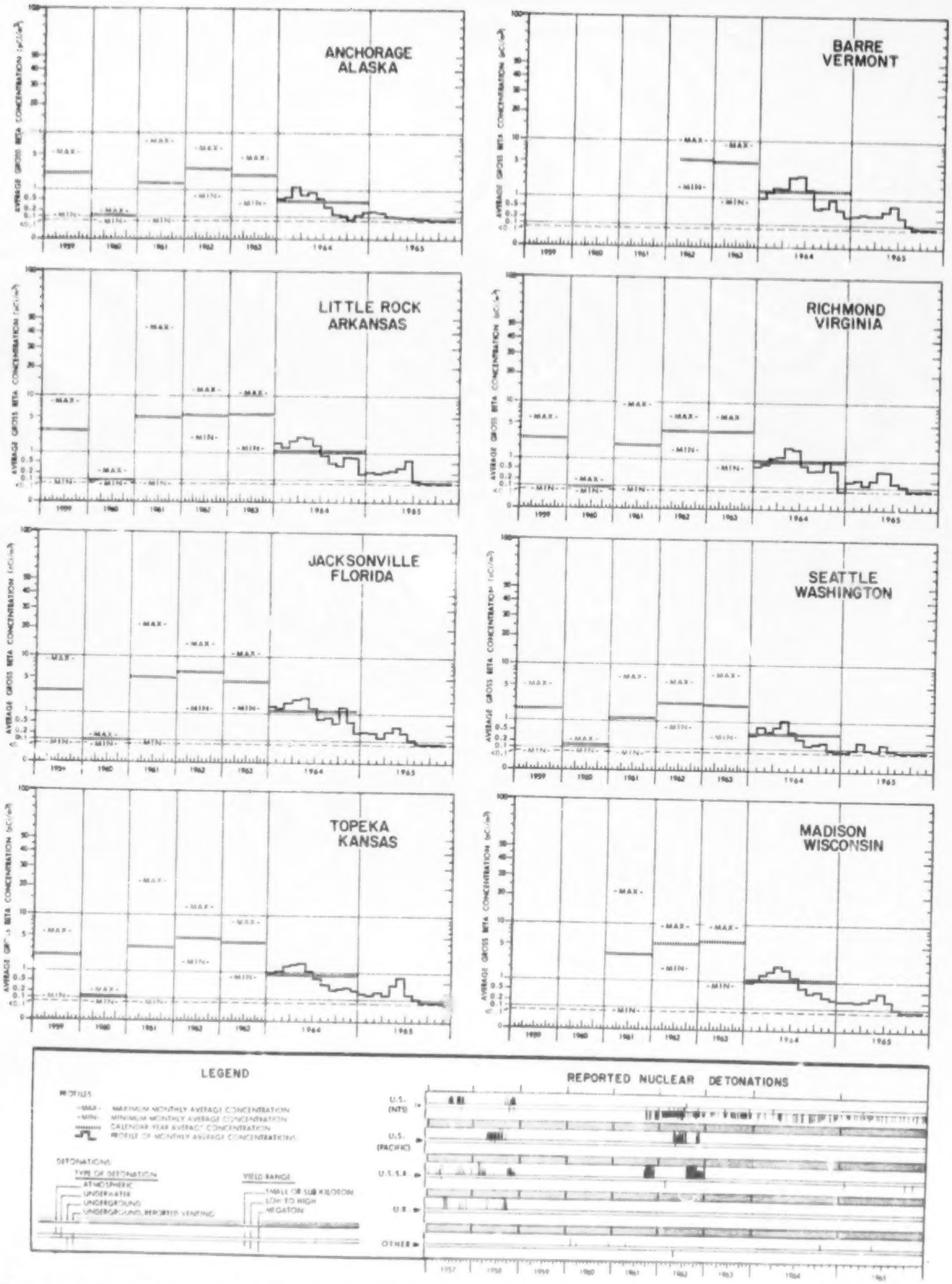

Figure 2. Monthly and yearly profiles of beta activity in air, Radiation Surveillance Network, 1959–November 1965

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2. Canadian Air and Precipitation Monitoring Program, November 1965[1]

Radiation Protection Division
Department of National Health and Welfare
Ottawa, Canada

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (see figure 3), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

A summary of the sampling procedures and methods of analysis was presented in the December 1965 issue of *Radiological Health Data.*

Surface air and precipitation data for November 1965 are presented in table 2. Specific radionuclide data are presented in table 3.

Table 2. Canadian gross beta activity in surface air and precipitation, November 1965

Station	Air Surveillance				Precipitation measurements	
	Number of samples	Activity (pCi/m^3)			Average concentration (pCi/liter)	Total deposition (nCi/m^2)
		Maximum	Minimum	Average		
Calgary	30	0.2	0.0	0.1	37	1.2
Coral Harbour	30	0.1	0.0	0.0	73	0.7
Edmonton	30	0.1	0.0	0.1	38	0.7
Ft. Churchill	29	0.1	0.0	0.0	31	0.8
Ft. William	30	0.1	0.0	0.0	21	1.7
Fredericton	30	0.1	0.0	0.0	16	2.2
Goose Bay	30	0.1	0.0	0.0	28	2.1
Halifax	29	0.1	0.0	0.1	27	3.0
Inuvik	30	0.1	0.0	0.1	42	0.5
Montreal	29	0.1	0.0	0.1	20	2.6
Moosonee	30	0.1	0.0	0.0	35	1.4
Ottawa	30	0.1	0.0	0.0	15	1.5
Quebec	29	0.1	0.0	0.0	20	2.7
Regina	30	0.1	0.0	0.1	38	0.9
Resolute	26	0.2	0.0	0.0	346	1.9
St. John's, Nfld	29	0.1	0.0	0.0	22	3.8
Saskatoon	30	0.1	0.0	0.0	29	0.5
Sault Ste. Marie	26	0.1	0.0	0.1	19	2.9
Toronto	30	0.1	0.0	0.1	37	2.7
Vancouver	30	0.1	0.0	0.0	30	3.7
Whitehorse	30	0.1	0.0	0.1	50	1.0
Windsor	30	0.1	0.0	0.1	45	1.9
Winnipeg	29	0.1	0.0	0.1	34	1.5
Yellowknife	30	0.1	0.0	0.0	13	0.4
Network summary	—	0.2	0.0	0.0	44	1.8

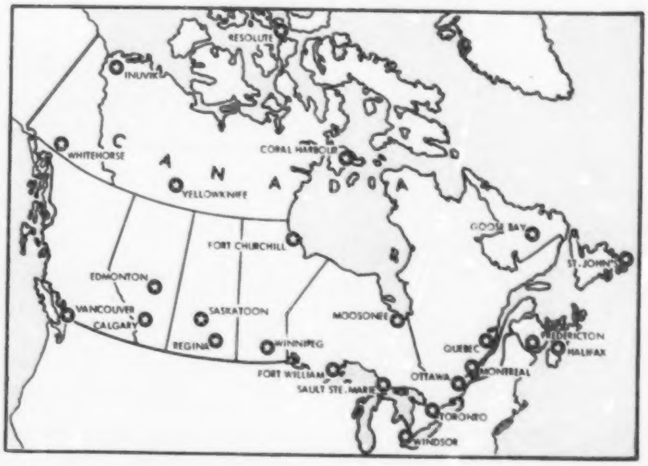
RESOLUTE
INUVIK
C A N A D A
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
SASKATOON
VANCOUVER
CALGARY
MOOSONEE
FREDERICTON
REGINA
WINNIPEG
QUEBEC
HALIFAX
FORT WILLIAM
MONTREAL
OTTAWA
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data in the December 1965 monthly report "Data from Radiation Protection Programs," Canadian Department of National Health and Welfare, Ottawa, Canada.

Table 3. Radionuclide deposition, nCi/m², in Canadian fallout, November 1965[a]

Station	^{90}Sr	^{137}Cs
Calgary	0.07	0.20
Coral Harbour	0.08	0.18
Edmonton	0.03	0.08
Ft. Churchill	0.03	0.06
Ft. William	0.05	0.15
Fredericton	0.11	0.21
Goose Bay	0.09	0.21
Halifax	0.22	0.43
Inuvik	0.01	0.08
Montreal	0.16	0.22
Moosonee	0.11	0.15
Ottawa	0.10	0.22
Quebec	0.15	0.47
Regina	0.03	0.06
Resolute	0.12	0.19
St. John's, Nfld	0.35	0.55
Saskatoon	0.04	0.06
Sault Ste. Marie	0.10	0.50
Toronto	0.22	0.30
Vancouver	0.30	0.49
Whitehorse	0.07	0.13
Windsor	0.11	0.20
Winnipeg	0.09	0.06
Yellowknife	0.02	0.04
Average	0.11	0.22

[a] Strontium-89, zirconium-95 and barium-140 are not reported due to insignificant levels.

3. Mexican Air Monitoring Program November 1965

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico is operated by the Comisión Nacional de Energía Nuclear (CNEN), Mexico City. From 1952 to 1961, an earlier network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN (*8–12*).

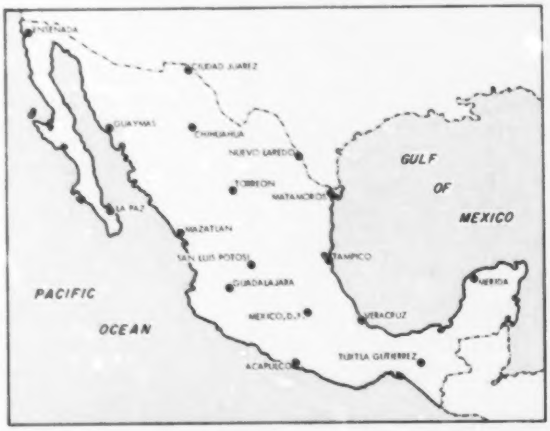

Figure 4. Fallout network sampling stations in Mexico

The new Radiation Surveillance Network, operated by CNEN's Division of Radiological Protection, consists of 17 stations (see figure 4), 12 of which are located at airports and operated by airline personnel. The remaining five stations are operated by staff members of other agencies.

Sampling procedures were discussed in detail in the December 1965 issue of *Radiological Health Data.*

Table 4 presents the maximum, minimum, and average gross beta activity concentrations in surface air during November 1965.

Table 4. Gross beta activity of airborne particulates, Mexico, November 1965

Station	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average
Acapulco[a]				
Ciudad Juárez	20	0.3	<0.1	0.1
Chihuahua	19	0.2	<0.1	0.1
Enseñada	12	0.2	<0.1	0.1
Guadalajara	12	0.1	<0.1	<0.1
Guaymas	15	0.1	<0.1	<0.1
La Paz	4	<0.1	<0.1	<0.1
Matamoros	1			
Mazatlán	2	<0.1	<0.1	<0.1
Mérida	11	0.1	<0.1	<0.1
México, D.F.	13	0.1	<0.1	<0.1
Nuevo Laredo	9	0.2	<0.1	<0.1
San Luis Potosí	15	0.1	<0.1	<0.1
Tampico	20	0.2	<0.1	<0.1
Torréon	26	0.2	<0.1	<0.1
Tuxtla Gutiérrez[a]				
Veracruz	6	0.1	<0.1	0.1

[a] Temporarily shut down.

4. Pan American Air Sampling Program November 1965

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by countries in the Americas under the auspices of a collaborative program developed by the Pan American Health Organization (PAHO) and the Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network. The air sampling station profiles are shown in figure 5.

The November 1965 air monitoring results from the participating countries are given in table 5.

Table 5. Gross beta activity in surface air, PAHO November 1965

Station locations	Number of samples	Gross beta activity, pCi/m³		
		Maximum	Minimum	Average [a]
Argentina: Buenos Aires	15	0.16	<0.10	<0.11
Chili: Santiago	30	<0.10	<0.10	<0.10
Jamaica: Kingston	12	<0.10	<0.10	<0.10
Peru: Lima	(b)			
Venezuela: Caracas	22	<0.10	<0.10	<0.10
West Indies: Trinidad	21	<0.10	<0.10	<0.10
Pan American summary	100	0.16	<0.10	<0.10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the < values represent more than 10 percent of the average, a less-than sign is placed before the average.

[b] Indicates no report received

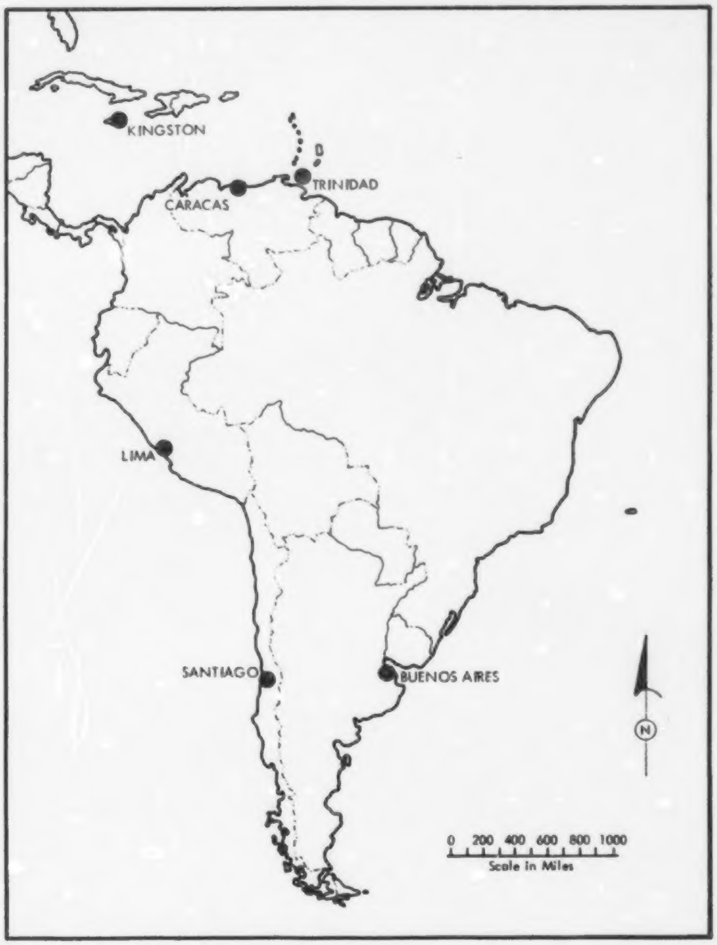

Figure 5. Pan American Air Network sampling stations

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Section IV. Other Data

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included are such data as those obtained from human bone sampling, bovine thyroid sampling, and environmental monitoring reports.

RADIONUCLIDES IN ALASKAN CARIBOU AND REINDEER, 1963–1965

Division of Radiological Health
Public Health Service

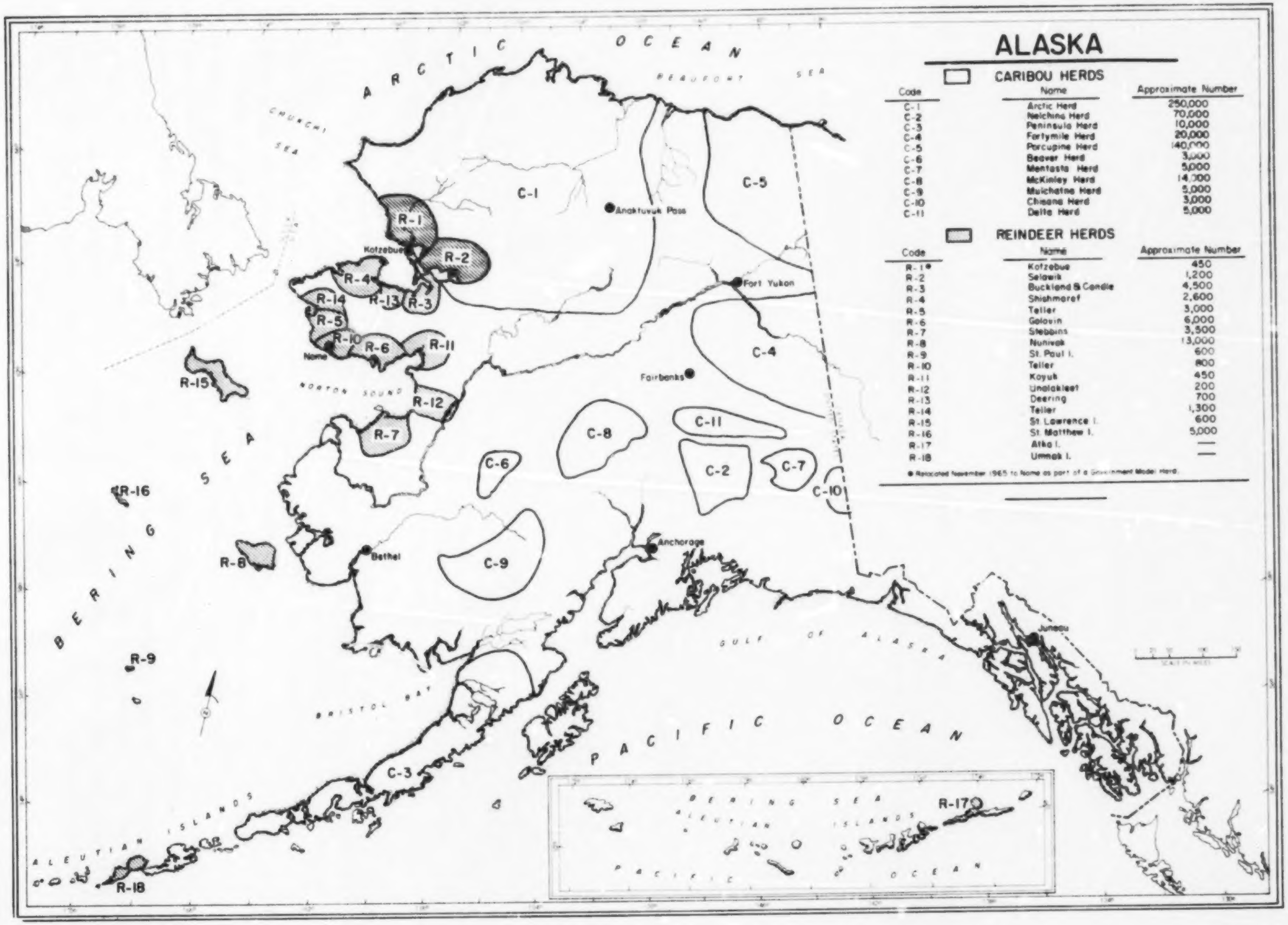
Under a cooperative agreement between the Alaskan Departments of Health and Welfare and of Fish and Game, and the Public Health Service, an active program of caribou and reindeer sampling and analysis was undertaken in 1963 to aid in the assessment of radionuclide intake of Alaskan residents. The basis for this joint sampling activity was a limited sampling effort conducted by these groups in 1962.

Through the second quarter of 1964, the sampling was confined to the three principal caribou (*Rangifer caribou*) herds and one privately owned reindeer (*Rangifer tarandus*) herd. This program was expanded when, beginning in September 1964, the sampling of additional privately owned reindeer herds was begun through the assistance of the Fish and Wildlife Service and Bureau of Indian Affairs, Department of Interior.

Figure 1 shows the locations and approximate number of animals in the caribou and reindeer herds sampled. In general, the reindeer herds are located on or near the Seward Peninsula and on two islands off the western coast of Alaska.

Samples of muscle, rumen contents, and bone from five animals (2- or 3-years old) in each herd sampled are collected in approximately April, July, September, and December of each year. The muscle samples, weighing about 2 pounds each, are frozen for shipment. The bone samples consist of the hock from each animal. The rumen content samples, weighing about 2 pounds wet, are frozen for shipment. All samples are shipped in dry ice to the Public Health Service Southwestern Radiological Laboratory in Las Vegas, Nevada, for analysis.

The analytical procedure includes gamma-


ALASKA
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
BERING SEA
NORTON SOUND
BRISTOL BAY
GULF OF ALASKA
PACIFIC OCEAN
ALEUTIAN ISLANDS
Kotzebue
Nome
Anaktuvuk Pass
Fort Yukon
Fairbanks
Bethel
Anchorage
Juneau
C-1
C-2
C-3
C-4
C-5
C-6
C-7
C-8
C-9
C-10
C-11
R-1
R-2
R-3
R-4
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R-12
R-13
R-14
R-15
R-16
R-17
R-18

ALASKA

▭ CARIBOU HERDS

Code	Name	Approximate Number
C-1	Arctic Herd	250,000
C-2	Nelchina Herd	70,000
C-3	Peninsula Herd	10,000
C-4	Fortymile Herd	20,000
C-5	Porcupine Herd	140,000
C-6	Beaver Herd	3,000
C-7	Mentasta Herd	5,000
C-8	McKinley Herd	14,000
C-9	Mulchatna Herd	5,000
C-10	Chisana Herd	3,000
C-11	Delta Herd	5,000

▨ REINDEER HERDS

Code	Name	Approximate Number
R-1*	Kotzebue	450
R-2	Selawik	1,200
R-3	Buckland & Candle	4,500
R-4	Shishmaref	2,600
R-5	Teller	3,000
R-6	Golovin	6,000
R-7	Stebbins	3,500
R-8	Nunivak	13,000
R-9	St. Paul I.	600
R-10	Teller	800
R-11	Koyuk	450
R-12	Unalakleet	200
R-13	Deering	700
R-14	Teller	1,300
R-15	St Lawrence I.	600
R-16	St Matthew I.	5,000
R-17	Atka I.	—
R-18	Umnak I.	—

* Relocated November 1965 to Nome as part of a Government Model Herd.

Figure 1. Location and numbers of caribou and reindeer in herds sampled

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Table 1. Average radionuclide values in caribou and reindeer muscle

Specimens and sampling dates	Number of samples	pCi/kg wet weight			
		Strontium-89	Strontium-90	Cesium-137	
				Average	Range
Caribou					
Arctic herd					
12/21/63	3	[a]<5	[a]17	4,860	3,750- 5,680
4/27-5/[illegible]/64	5	[a]<5	[a]400	13,800	5,000-21,000
8/20-8/29/64	5	[a]<5	[a]40	700	400- 1,000
12/7-12/15/64	5	[a]<5	[a]19	3,900	1,400- 5,300
4/14/65	5	[a]<5	[a]22	9,600	6,300-14,000
9/20-10/2/65	5	[a]<5	[a]11	7,720	4,000-12,000
11/16-11/22/65	5	[a]5	[a]1	6,220	4,300- 7,400
Nelchina herd					
11/24-11/25/63	5	[a]5	[a]33	21,800	16,900-26,400
4/24-4/26/64	5	[a]10	[a]54	5,560	2,600-10,000
8/26/64	1	<5	31	14,300	
10/15/64	9	[a]5	[a]20	4,220	650- 6,200
12/8-12/9/64	5	[a]<5	[a]30	14,000	7,900-22,000
3/27/65	5	[a]<5	[a]48	27,600	16,000-39,000
7/27-7/28/65	5	[a]<5	[a]7	4,000	1,600- 7,300
9/25-9/29/65	5	<5	[a]26	8,160	5,900-10,000
12/4/65	5	<5	[a]33	17,200	14,000-22,000
Peninsula herd					
12/12-12/19/63	5	[a]10	[a]84	44,800	33,600-57,700
4/9-4/15/64	5	[a]<5	[a]14	14,800	13,000-18,000
7/11/64	4	[a]<5	[a]5	1,680	1,400- 2,000
9/26-10/1/64	5	[a]<5	[a]11	4,630	1,200- 9,250
12/14-12/17/64	5	[a]<5	31	18,000	8,700-31,000
8/26/65	5	[a]<5	[a]4	2,000	820- 3,200
9/29/65	5	[a]<5	[a]15	18,000	11,000-32,000
11/10/65	5	[a]<5	[a]7	20,100	12,400-25,000
Reindeer					
R-1					
12/27/63	4	[a]5	[a]31	7,190	6,730- 7,540
9/7/64	5	[a]5	[a]74	3,340	2,300- 4,900
12/15/64	4	[a]5	[a]268	23,000	13,000-30,000
R-2					
12/15/64	1	5	578	34,000	
R-3					
9/26/64	2	[a]5	[a]68	19,600	13,400-25,800
12/15/64	4	[a]5	[a]64	14,000	5,100-32,000
R-4					
9/25/64	3	[a]5	[a]38	8,490	7,660-10,000
12/15/64	5	[a]5	[a]68	12,000	4,900-29,000
3/6/65	5	[a]5	[a]25	18,000	13,000-24,000
9/2/65	5	[a]<5	[a]14	6,000	4,000- 8,100
11/30/65	5	[a]<5	[a]25	16,800	14,000-22,000
R-5					
12/15/64	5	[a]<5	[a]66	35,000	25,000-47,000
11/30/65	5	[a]<5	[a]90	27,000	23,000-35,000
R-6					
12/15/64	5	[a]<5	[a]96	19,000	11,000-30,000
R-7					
12/24/64	5	[a]<5	[a]86	30,000	14,000-37,000
R-8					
9/18/64	5	[a]<5	[a]75	7,050	5,000- 9,200
12/24/64	5	[a]<5	[a]128	25,000	9,800-35,000
4/1/65	5	[a]<5	[a]28	31,200	27,000-34,000
8/18/65	35			7,700	4,000-15,000
R-9					
9/24/64	4	[a]<5	[a]10	4,860	2,080- 7,530
11/19-11/20/64	5	[b]—	[b]—	13,000	4,400-16,000
R-13					
12/15/64	5	[a]<5	[a]127	28,000	23,000-34,000

[a] Indicates samples composited before analysis.
[b] Dash indicates no analysis.

scintillation spectrometry for cesium-137 and other gamma emitters. Strontium-89 and strontium-90 are determined by chemical separation followed by beta counting. Analysis for stable calcium is done by a flame-photometric method.

Strontium-89, strontium-90, and cesium-137 data are presented in tables 1-3 for caribou and reindeer muscle, rumen contents, and bone, respectively, for the period November 1963 through December 1965.

The muscle data are of prime interest since muscle, in contrast to rumen or bone, is an important constituent of the diet for many

Table 2. Average radionuclide values in Alaskan caribou and reindeer rumen contents

Specimens and sampling dates	Number of samples	pCi/kg wet weight			
		Strontium-89	Strontium-90	Cesium-137	
				Average	Range
Caribou					
Arctic herd					
12/21/63	3	[a] 500	[a] 4,440	4,430	3,980-4,770
4/27-5/19/64	5	[a] <5	[a] 1,680	4,440	4,000-6,000
8/20-8/29/64	5	[a] 40	[a] 1,700	1,470	970-2,200
10/2-10/23/64	5	[a] <5	[a] 4,500	5,080	4,400-6,100
12/7-12/15/64	5	[a] <5	[a] 4,020	4,100	1,800-6,300
4/14/65	5	[b] —	[b] —	[a] 8,400	
9/20-10/2/65	5	[b] —	[b] —	[a] 4,700	
11/16/65	5	[b] —	[b] —	[a] 5,000	
Nelchina herd					
11/24-11/25/63	5	[a] 400	[a] 5,150	4,880	1,100-7,430
4/24-4/26/64	5	[a] <5	[a] 1,550	8,400	2,500-12,000
8/26/64	1	<5	346	8,900	
10/15/64	9	[a] <5	[a] 207	3,030	550-4,500
12/8-12/9/64	5	[a] <5	[a] 4,430	7,200	4,300-9,000
3/27/65	5	[b] —	[b] —	[a] 8,600	
7/27-7/28/65	5	[b] —	[b] —	[a] 5,100	
9/25-9/29/65	5	[b] —	[b] —	[a] 7,300	
12/4/65	5	[b] —	[b] —	[a] 6,500	
Peninsula herd					
12/12-12/19/63	5	[a] 1,550	[a] 5,700	7,920	4,020-12,300
4/9-4/15/64	5	[a] <5	[a] 1,300	1,840	1,400-2,600
7/11/64	5	[a] <5	[a] 311	690	620-740
9/26-10/1/64	5	[a] <5	[a] 825	5,800	1,500-13,300
12/14-12/17/64	5	[a] 3,120	[a] 2,410	4,900	2,200-8,000
8/26/65	5	[a] <5	[a] 487	[a] 770	
9/26/65	5	[b] —	[b] —	[a] 6,600	
11/10/65	5	[b] —	[b] —	[a] 8,100	
Reindeer					
R-1					
12/27/63	4	[a] <5	[a] 5,600	4,650	3,760-5,360
12/15/64	5	[a] <5	[a] 4,480	5,400	2,300-7,900
R-2					
12/15/64	1	<5	3,910	6,900	
R-3					
9/26/64	1	<5	315	10,900	
12/15/64	3	[a] <5	[a] 5,810	5,500	5,200-5,700
R-4					
9/25/64	1	<5	1,710	5,770	
12/15/64	5	[a] <5	[a] 2,440	1,900	1,000-2,700
11/30/65	5	[b] —	[b] —	[a] 5,000	
R-5					
11/30/65	5	[b] —	[b] —	[a] 5,600	
R-8					
9/18/64	5	[a] 5	[a] 3,060	3,600	2,500-4,510
12/24/64	5	[a] <5	[a] 4,040	5,400	1,100-10,000
R-9					
9/24/64	4	[a] <5	[a] 720	1,070	600-1,900
11/19-11/20/64	5	[b] —	[b] —	4,400	1,700-8,500
R-11					
12/15/64	5	[a] <5	[a] 4,930	4,600	2,400-7,400

[a] Indicates samples composited before analysis.
[b] Dash indicates no analysis.

Alaskan residents. A tendency toward increased cesium-137 values in caribou and reindeer muscle during and immediately following the winter diet and lower values during and immediately following the summer diet can be seen. Also, a trend is noted in caribou muscle values with the Peninsula herd reaching the highest concentrations in the winter months and the Nelchina herd following. However, the concentration of cesium-137 decreases sooner in these animals than the Arctic herd because of an earlier spring where they graze.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
1962-1964	*December 1964*
1963-1964	*May 1965*

Table 3. Average radionuclide values in Alaskan caribou and reindeer bone

Specimens and sampling dates	Number of samples	pCi/g ash		pCi/kg wet weight	
		Strontium-89	Strontium-90	Cesium-137	
				Average	Range
Caribou					
Arctic herd					
12/21/63	3	[a] 60	[a] 225	170	120-210
4/27-5/19/64	5	[a] <5	[a] 143	[b] —	
8/20-8/29/64	5	[a] <5	[a] 137	[b] —	
10/2-10/23/64	5	[a] <5	[a] 128	714	510-920
12/7-12/15/64	5	[a] <5	[a] 125	[b] —	
4/11-4/14/65	5				
11/16-11/22/65	5				
Nelchina herd					
11/24-11/25/63	5	[a] <5	[a] 117	920	520-1,940
4/24-4/26/64	5	[a] <5	[a] 143	[b] —	
10/15/64	9	[a] <5	[a] 84	790	470-1,000
12/8/64	5	[a] <5	[a] 69	[b] —	
12/4/65	5				
Peninsula herd					
12/12-12/19/63	5	[a] <5	[a] 118	3,920	3,240-4,780
4/9-4/15/64	5	[a] <5	[a] 116	[b] —	[c] ND-2,180
9/26-10/1/64	5	[a] <5	[b] 114	810	
7/11/64	4	[a] <5	[a] 115	[b] —	
12/14-12/17/64	5	[a] <5	[a] 169	[b] —	
8/26/65	5	[a] <5	[a] 776	[b] —	
11/10/65	4				
Reindeer					
R-1					
12/27/63	4	[a] 25	[a] 64	830	750-920
9/7/64	5	[a] <5	[a] 96	2,240	1,300-2,700
12/15/64	5	[a] <5	[a] 116	[b] —	
R-2					
12/15/64	1	<5	105	[b] —	
R-3					
9/26/64	2	[a] <5	[a] 184	3,670	1,880-5,460
12/15/64	5	[a] 7	[a] 175	[b] —	
R-4					
9/25/64	3	[a] <5	[a] 115	2,050	1,080-2,880
12/15/64	5	[a] <5	[a] 135	[b] —	
R-5					
12/15/64	4	[a] <5	[a] 185	[b] —	
R-6					
12/15/64	5	[a] <5	[a] 197	[b] —	
R-7					
12/24/64	5	[a] <5	[a] 269	[b] —	
R-8					
9/18/64	5	[a] <5	[a] 185	1,420	1,060-1,790
12/24/64	5	[a] <5	[a] 178	2,000	360-3,700
R-9					
9/24/64	4	[a] <5	[a] 64	460	340-610
11/19-11/20/64	5	[a] <5	[a] 214	750	400-880
R-11					
12/15/64	5	[a] <5	[a] 214	[b] —	
R-13					
12/15/64	5	[a] <5	[a] 177	[b] —	

[a] Indicates samples composited before analysis.
[b] Dash indicates no analysis.
[c] ND indicates not detectable.

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U.S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Argonne National Laboratory, Atomics International, Feed Materials Production Facilities, and National Reactor Testing Station.

1. Argonne National Laboratory
January–June 1965[2]

University of Chicago
Lemont, Illinois

The radioactivity of the environment is determined on a continuing basis by measuring the radioactivity in naturally occurring materials collected both on and off the Argonne National Laboratory site. Since radioactivity is usually spread by air and water, the environmental monitoring program at Argonne has concentrated on these materials. The sampling locations discussed in this report are shown in figures 1 and 2.

Air monitoring

Air-filter samples were collected continuously at seven locations on the Argonne site and at five locations off the site. Sampling on charcoal for radioactive iodine was conducted on the site only. Iodine activity in excess of the minimum detectable concentration of 0.2 pCi/m^3 (0.2 percent of the MPC[1]) was not detected. The total alpha and beta activities in the air-filter samples are summarized in table 1. No activity attributable to Argonne operations was found in any of these samples. The alpha activities were normal both on and off the site and were in the range found in previous years. The beta activity was due prin-

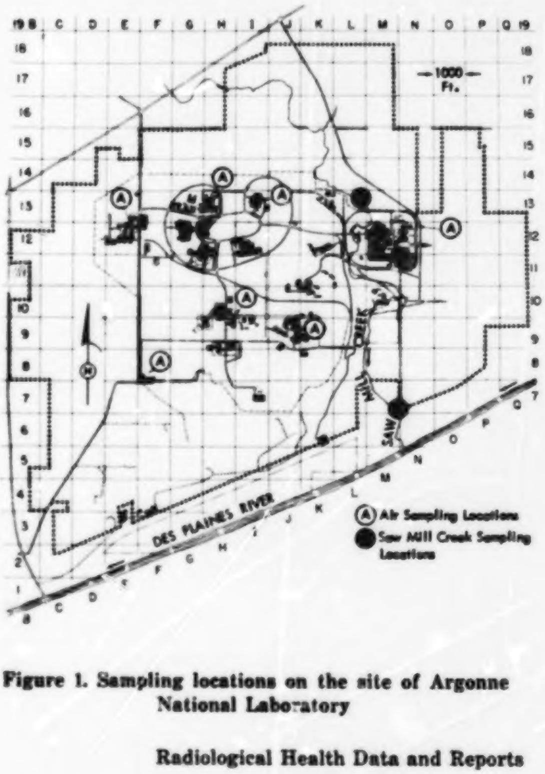

Figure 1. Sampling locations on the site of Argonne National Laboratory

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[1] Part 20, "Standards for Protection Against Radiation," AEC Rules and Regulations, contains essentially the standards published in the "AEC Manual." The AEC Rules and Regulations are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, on a subscription basis at $3.50 for 3 years.

[2] Summarized from "Environmental Radioactivity at Argonne National Laboratory, January–June 1965," University of Chicago, Lemont, Illinois.

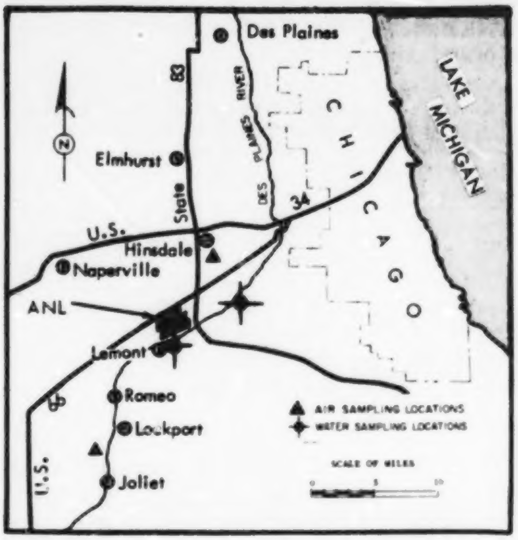

Figure 2. Sampling locations near Argonne National Laboratory

cipally to long-lived fission and neutron activation products from nuclear test detonations of previous years. In addition, short-lived fission products from a nuclear detonation conducted on the Chinese mainland on May 14, 1965, were present in air beginning on May 21. The increase in radioactivity due to this test was about 0.2 pCi/m³, about the same as that observed after the first Chinese test in October 1964. Concentrations of several fission products in air are given in table 2.

Water monitoring

Argonne waste water is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500 yards downstream from the waste water discharge. Sawmill Creek was sampled above and below the discharge to evaluate the effect of the waste water on the radio-

Table 1. Total alpha and beta activities in air-filter samples, January–June 1965 [a]

Month, 1965	Location	Number of samples	Alpha activity, pCi/m³			Beta activity, pCi/m³		
			Average	Minimum	Maximum	Average	Minimum	Maximum
January	Onsite	27	0.0039	0.0019	0.0070	0.2	0.1	0.3
	Offsite	23	0.0039	0.0019	0.0063	0.2	0.1	0.3
February	Onsite	21	0.0037	0.0004	0.0067	0.3	0.1	0.4
	Offsite	18	0.0038	0.0022	0.0061	0.3	0.2	0.4
March	Onsite	27	0.0033	0.0018	0.0079	0.3	0.2	0.5
	Offsite	18	0.0030	0.0013	0.0056	0.3	0.2	0.5
April	Onsite	25	0.0040	0.0017	0.0075	0.3	0.2	0.4
	Offsite	16	0.0045	0.0021	0.0075	0.3	0.2	0.5
May	Onsite	24	0.0037	0.0024	0.0070	0.4	0.2	0.7
	Offsite	17	0.0040	0.0023	0.0059	0.4	0.2	0.5
June	Onsite	25	0.0034	0.0021	0.0060	0.6	0.4	1.1
	Offsite	23	0.0038	0.0014	0.0057	0.7	0.4	1.2
Summary	Onsite	149	0.0037	0.0004	0.0079	0.4	0.1	1.1
	Offsite	115	0.0038	0.0013	0.0075	0.4	0.1	1.2

[a] These results were obtained by measuring the samples four days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products. This activity is normally present in the air and disappears within four days by radioactive decay.

Table 2. Gamma-ray activity in air-filter samples, January–June 1965, pCi/m³

Radionuclides	Location	January	February	March	April	May	June	Average
Antimony-125	Onsite	<0.01	0.01	0.01	0.01	0.01	0.01	0.01
	Offsite	<0.01	0.01	0.01	0.01	0.01	0.01	0.01
Barium-140-lanthanum-140	Onsite	<0.01	<0.01	<0.01	<0.01	0.05	0.09	0.03
	Offsite	<0.01	<0.01	<0.01	<0.01	0.06	0.11	0.03
Cerium-144	Onsite	0.06	0.09	0.11	0.11	0.11	0.15	0.11
	Offsite	0.07	0.11	0.13	0.11	0.13	0.16	0.12
Cesium-137	Onsite	0.01	0.02	0.02	0.03	0.03	0.03	0.02
	Offsite	0.02	0.02	0.02	0.03	0.03	0.03	0.02
Ruthenium-106-rhodium-106	Onsite	0.05	0.04	0.06	0.05	0.09	0.07	0.06
	Offsite	0.05	0.04	0.06	0.08	0.06	0.09	0.06
Zirconium-95-niobium-95	Onsite	<0.01	<0.01	<0.01	<0.01	0.01	0.04	0.01
	Offsite	<0.01	<0.01	<0.01	<0.01	0.01	0.05	0.01

activity in the creek. Radioactivity from Argonne waste water, in amounts well below the MPC's, was found in some samples of Sawmill Creek water collected below the discharge. The concentrations of radioactive materials at this location are summarized in table 3. The table gives the average and maximum concentrations in pCi/liter as well as the corresponding percentages of the MPC's.

A comparison of these concentrations with those above the discharge indicates that most of the uranium, thorium, plutonium, cesium-137, and cobalt-60 was added to the creek in the waste water while most of the strontium-90 was due to fallout.

Table 3. Radioactivity in Sawmill Creek water below waste water discharge, January–June 1965

Element or nuclide	Concentration (pCi/liter)		Percent of MPC	
	Average	Maximum	Average	Maximum
Barium-140	—	<2	—	<0.007
Cesium-137	1.1	3.3	0.006	0.017
Cobalt-58	—	<5	—	<0.005
Cobalt-60	1.6	14.1	0.003	0.028
Iodine-131	—	<3	—	<1
Plutonium	<0.05	0.34	<0.001	0.007
Strontium-89	—	<2	—	<0.02
Strontium-90	2.7	5.5	0.9	1.8
Thorium-232	0.11	0.81	0.005	0.041
Thorium-234–protactinium-234	1.9	7.7	0.010	0.039
Tritium	—	<4,000	—	<0.13
Uranium	2.7	10.6	0.007	0.027

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in these two streams is important in determining the effect of Argonne operations on the environmental radioactivity. The alpha, beta, and uranium activities found in these streams are summarized in table 4. Des Plaines River water was also analyzed for the other nuclides found in Sawmill Creek and, as was the case for the results in table 4, no significant differences in radioactivity between sampling locations of the river could be found. Apparently as a result of dilution, the activity in Sawmill Creek had no detectable effect on the radioactivity in the Des Plaines River. The alpha activities in the Des Plaines and Illinois Rivers were in the normal range and similar to earlier values. The natural beta activity in the Des Plaines and Illinois Rivers varies between 5 and 10 pCi/liter. The additional beta activity in these streams was due to fallout. There was no indication of activity from Argonne operations in either stream.

Table 4. Average radioactivity in waters of the Des Plaines and Illinois Rivers, pCi/liter, January–June 1965

Locations	Alpha activity	Uranium	Beta activity
Des Plaines River (above Sawmill Creek)[a]	2.4	1.8	20
Des Plaines River (below Sawmill Creek)[b]	2.3	1.5	20
Illinois River[c]	2.4	2.2	16

[a] Sampled near Highway Route 45, upstream from the mouth of Sawmill Creek.

[b] Sampled near Lemont, downstream from the mouth of Sawmill Creek.

[c] Average of two sampling locations: McKinley Woods State Park and Morris. See figure 2 for all sampling locations.

Milk monitoring

Three samples of raw milk produced in the area were analyzed monthly for a number of fisson products. The long-lived fission products, cesium-137, and strontium-90 were present in all samples. Their average concentrations were 80 and 14 pCi/liter, respectively. The shorter-lived fission products, barium-140 and strontium-89 were found only in the samples collected June 4, 1965, and are attributed to the Chinese test of May 14. The concentrations of these fission products in the June samples were 24 and 14 pCi/liter, respectively.

Summary

Fallout activity was present in all types of samples and at all locations throughout the year, but in lower concentration than in 1964. Argonne's contribution to the environment was confined to Sawmill Creek below the waste-water discharge. Radioactivity originating at Argonne was not found in any other material or at any other location off the site. The concentrations of radioactive substances added to the environment during the year by Argonne were considerably less than the MPC's and did not constitute a health hazard.

Previous coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1960	*July 1961*
January–June 1961	*December 1961*
July–December 1961	*May 1962*
Calendar year 1962	*May 1963*
Calendar year 1963	*August 1964*
January–June 1964	*March 1965*
July–December 1964	*September 1965*

2. Atomics International January–June 1965 [3]

North American Aviation, Inc.
Canoga Park, California

Atomics International, a Division of North American Aviation, Incorporated, has been engaged in atomic energy research and development since 1946. The company designs, develops, and constructs nuclear reactors for central station and compact power plants, and for medical, industrial, and scientific applications.

The company headquarters is located in Canoga Park, California, approximately 23 miles northwest of downtown Los Angeles. The 290-acre Nuclear Development Field Laboratory (Santa Susana Facility), equipped with extensive testing facilities for the support of advanced nuclear studies, is in Ventura County in the Simi Hills approximately 29 miles northwest of downtown Los Angeles. The location of the above sites in relation to nearby communities is shown in figure 3.

The basic concept of radiological hazard control at Atomics International encourages total containment of radioactive materials and, through rigid operational controls, minimizes effluent releases and external radiation levels. The environmental monitoring program provides a check on the effectiveness of radiological safety procedures and of engineering safeguards incorporated into facility design.

The environs of Atomics International headquarters and Nuclear Development Field Laboratory (NDFL), are surveyed monthly to determine the concentration of radioactivity in typical surface soil, vegetation, and water samples. In addition, continuous environmental air monitoring at the sites provides information concerning airborne particulate radioactivity.

Air monitoring

Environmental air sampling is conducted continuously at the headquarters and NDFL sites with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on a filter tape which is automatically changed at the end of each

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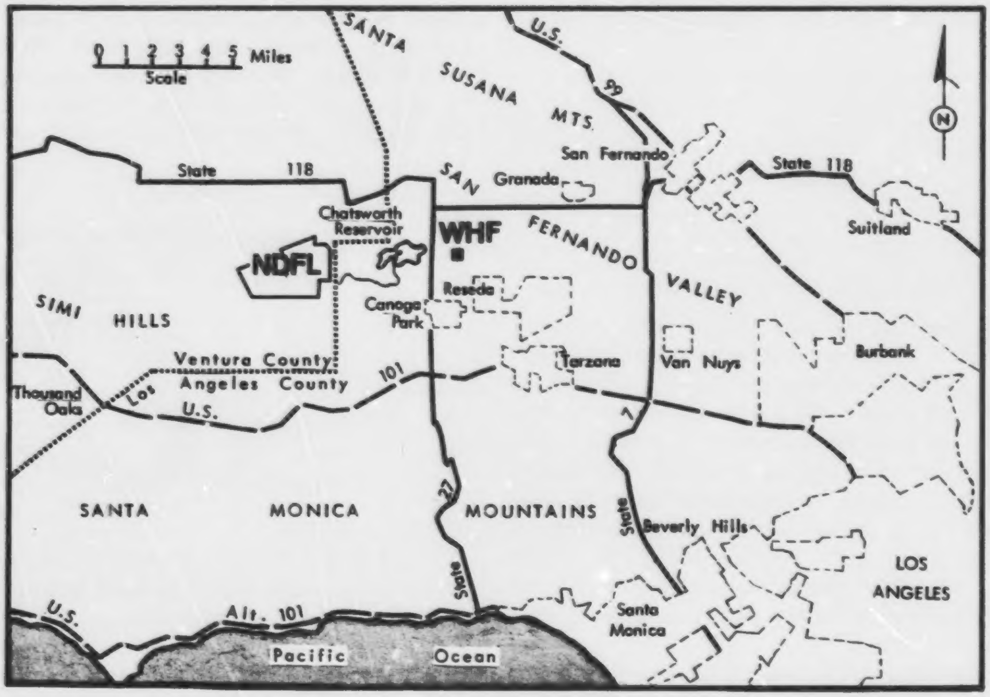
[3] Summarized from "Environmental Monitoring, Semiannual Report, January 1, 1965, to June 30, 1965," Atomics International.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WHF
NDFL
Reseda
Canoga Park
SIMI HILLS
Van Nuys
Burbank
Tarzana
Ventura County
Los Angeles County
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U.S.
Thousand Oaks
7
SANTA MONICA MOUNTAINS
27
State
State
Beverly Hills
LOS ANGELES
U.S.
Alt. 101
Santa Monica
Pacific Ocean

Figure 3. Atomics International Facilities and vicinity

sampling period. The filter is removed from the sampler and counted after the radioactivity is allowed to decay for at least 72 hours. The volume of a typical daily environmental air sample is approximately 21 cubic meters. The average concentration of airborne particulates is presented in table 5.

Table 5. Radioactivity of airborne particulates (beta-gamma activity, pCi/m^3)

Location	1964		First half 1965	
	Number of samples	Average concentration	Number of samples	Average concentration
Headquarters	355	2.7	182	2.0
NDFL	Insufficient data		69	1.9

Water monitoring

Process water used at the NDFL is obtained from wells and stored in 50,000-gallon tanks. Potable water is delivered to the site by a vendor and is not analyzed. Well water is sampled monthly from the supply line at two locations. The average well water radioactivity is presented in table 6.

Table 6. Well water radioactivity—NDFL (pCi/liter)

Activity	1964		First half 1965	
	Number of samples	Average concentration	Number of samples	Average concentration
Alpha	23	<0.18	12	0.22
Beta-gamma	23	<5.3	12	6.5

Soil, vegetation, and water are sampled monthly at Chatsworth Reservoir, which is operated by the Los Angeles City Department of Water and Power. Soil and vegetation radioactivity data for the reservoir is averaged into data presented in tables 7 and 8. Normally, one water sample is obtained from the lake surface and a second sample is obtained from the reservoir supply inlet located on the north side of the lake. The average radioactivity for both surface and supply water samples is presented in table 9.

In the laboratory, 500 ml of water is evaporated to dryness in crystallizing dishes at approximately 90°C. The residue salts are transferred to stainless-steel planchets, wetted with distilled water to produce a uniform sample distribution, redried under infrared lamps, and counted.

Soil and vegetation monitoring

Soil and vegetation are sampled monthly at 24 locations. Twelve sampling stations are located within the boundaries of Atomics International's sites and are referred to as "onsite" stations. The remaining 12 stations, located within a 10-mile radius of the sites, are referred to as "offsite" stations.

Surface soil types available for sampling range from decomposed granite to clay and loam. Samples are taken from the top half-inch layer of ground surface. The soil samples are packaged and sealed in plastic containers and returned to the laboratory for analysis.

Sample preparation consists of transferring the soils to Pyrex beakers and drying in a muffle furnace at 500°C. for approximately 8 hours. After cooling, the soil is sieved to obtain a uniform particle size. One-gram aliquots of the sieved soil are weighed and transferred to stainless-steel planchets. The soil is wetted in the planchet with acetone, agitated to obtain uniform sample thickness, redried and counted. Radioactivity in soil is presented in table 7.

Table 7. Radioactivity in the soil (pCi/g)

Area	Activity	1964		First half 1965	
		Number of samples	Average concentration	Number of samples	Average concentration
Onsite	Alpha	152	<0.46	72	0.49
	Beta-gamma	146	32	72	24
Offsite	Alpha	299	<0.44	70	<0.51
	Beta-gamma	293	26	70	17

Vegetation samples obtained in the field are of the same plant type wherever possible, generally sunflower or wild tobacco plant leaves. These types maintain a more active growth rate during the dry season than do most natural vegetation indigenous to the local area.

Vegetation leaves are stripped from plants and placed in ice cream cartons for transfer to the laboratory for analysis. Plant root systems are not routinely sampled.

Vegetation samples are first washed with tap water to remove foreign matter and then thoroughly rinsed in distilled water. Washed vegetation is placed in porcelain crucibles and ashed in a muffle furnace at 500°C. for approximately 8 hours, producing a completely oxidized ash. Three hundred milligram aliquots of pulverized ash from each crucible are weighted and transferred to stainless-steel planchets for counting. Radioactivity in vegetation is presented in table 8.

Table 8. Radioactivity in vegetation (pCi/g ash)

Area	Activity	1964		First half 1965	
		Number of samples	Average concentration	Number of samples	Average concentration
Onsite	Alpha	154	<0.50	72	<0.62
	Beta-gamma	148	211	72	177
Offsite	Alpha	293	<0.51	70	0.78
	Beta-gamma	299	181	70	156

Table 9. Chatsworth Reservoir water radioactivity (pCi/liter)

Sample	Activity	1964		First half 1965	
		Number of samples	Average concentration	Number of samples	Average concentration
Lake surface	Alpha	18	0.71	6	0.53
	Beta-gamma	18	10	6	9.8
Supply inlet	Alpha	12	0.49	6	0.44
	Beta-gamma	12	8.8	6	12.2

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
1960 and first half of 1961	*December 1961*
Second half 1961	*August 1962*
Calendar year 1962	*November 1963*
Calendar year 1963	*September 1964*
First half 1964	*March 1965*
Second half 1964	*September 1965*

3. Feed Materials Production Facilities January–December 1964 [1]

Mallinckrodt Chemical Works
Weldon Spring, Missouri

Environmental monitoring results at the Feed Materials Production Facilities (FMPF) are reported in uranium concentrations since uranium ore concentrates constitute the primary feed material.

Process chemical wastes and other process residues are permanently retained in storage facilities (figure 4) located at the plant site and at two storage sites (one adjacent to the Lambert-St. Louis Municipal Airport and the other at a quarry near the Missouri River). The plant process sewer, which carries the remaining water effluent from the operations into the Missouri River, is automatically sampled daily to permit continual measurement of any release of uranium-bearing material into the river.

Air monitoring

One 24-hour air sample per month is collected along the plant perimeter by each of nine high-volume sampling pumps (see figure 5). Semiannual air samples are collected at four points on the perimeter of the airport storage site, and monthly air samples are collected at the south edge of the quarry. Semiannual average uranium concentrations are reported in table 10. The average uranium concentration noted in perimeter air samples collected in 1964 did not change significantly from the average obtained during the 1963 sampling period. The average uranium concentration of these samples continued to remain below one-tenth of the MPC for air or nonoccupational areas. Averages ranged from 0.15 percent to 24 percent of the environmental MPC for uranium in air.

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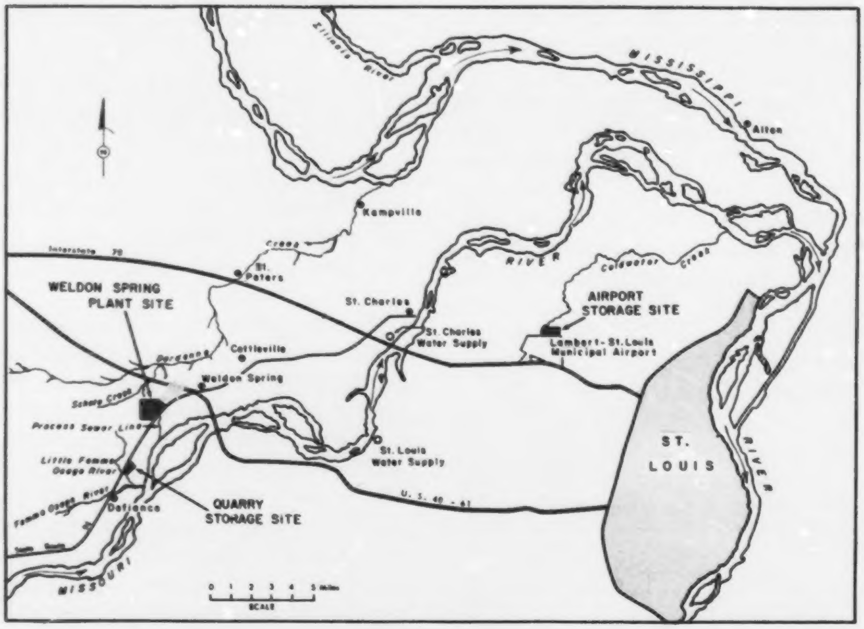
[1] Summarized from "First Semiannual Off-site Environmental Monitoring Report–1964" and "Second Semiannual Off-site Environmental Monitoring Report–1964," Weldon Spring Plant, Mallinckrodt Chemical Works, Uranium Division.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St. Charles
RIVER
Coldwater Creek
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St. Charles Water Supply
Lambert-St. Louis Municipal Airport
Cottleville
Dardenne
Weldon Spring
Schote Creek
Process Sewer Line
Little Femme Osage River
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Figure 4. Location of Feed Materials Production Facilities, Weldon Spring, Missouri

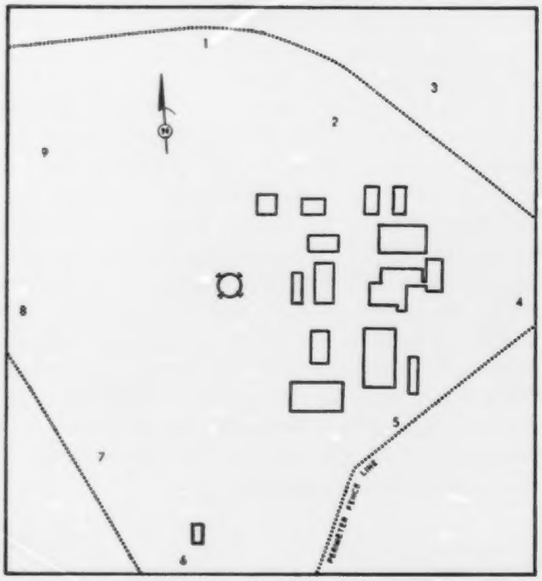
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Figure 5. Perimeter air sampling stations, Weldon Spring Plant

Table 10. Uranium concentrations in air, FMPF (average concentrations in pCi/m³)

Site	Station locations	First half 1965		Second half 1965	
		Number of samples	Uranium concentration	Number of samples	Uranium concentration
Plant	1	4	0.22	1	0.27
	2	6	0.30	3	0.23
	3	5	0.20	3	0.015
	4	3	0.12	1	0.05
	5	6	0.13	3	0.02
	6	6	0.03	3	0.02
	7	4	0.08	1	0.47
	8	4	0.10	1	0.12
	9	3	0.32	1	0.15
	Average	—	0.163	—	0.113
Quarry	South edge	5	0.08	2	0.04
Airport	North	1	0.09	—	NS
	West	1	0.05	—	NS
	East	1	0.08	—	NS
	South	1	0.03	—	NS

NS, no sample collected

Water monitoring

In addition to daily samples from the plant process sewer, monthly offsite water samples are collected from lakes and streams located within the plant's watershed, the Missouri

River, and streams near the quarry, and airport storage area site at the points indicated in table 11. Average uranium concentrations ranged from 0.01 percent to 5.2 percent of the environmental MPC. These concentrations are similar to those observed in 1963.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
January 1959–March 1960	*November 1960*
July 1960–June 1961	*November 1961*
July–December 1961	*July 1962*
January–June 1962	*November 1962*
July 1962–December 1963	*May 1964*

Table 11. Uranium concentrations in water, FMPF

(average concentrations in pCi/liter)

Sampling locations	First half 1964		Second half 1964	
	Number of samples	Uranium concentration	Number of samples	Uranium concentration
Weldon Spring Plant Site:				
Process sewer	123	420	118	1,040
Plant offsite sampling points:				
Lake, east of plant	2	4	2	3
Lake, north of plant	2	2	2	5
Lake, west of plant	2	2	2	2
Lake, south of plant	2	6	2	4
Dardenne Creek, upstream	2	3	2	3
Dardenne Creek, Cottleville bridge	2	4	2	4
Dardenne Creek, St. Peters' bridge	2	2	2	4
Dardenne Creek, Kampville bridge	2	2	2	3
Schote Creek, upstream	2	3	2	6
Schote Creek, downstream	6	11	6	5
Plant surface drainage, west	6	680	6	200
Plant surface drainage, north	6	170	6	200
Missouri River sampling points.				
Upstream at Defiance	2	2	2	4
Upstream at Femme Osage junction	2	11	2	5
U.S. Highway 40–61, south side	2	2	2	4
St. Louis city water plant intake	2	2	2	4
St. Charles city water plant intake	2	3	2	3
Quarry offsite sampling points:				
Tributary of Little Femme Osage, ¼ mile upstream	2	6	2	6
Little Femme Osage, ¼ mile upstream	2	2	2	3
Little Femme Osage at quarry discharge culvert	6	2	6	4
Little Femme Osage, ¼ mile downstream	2	2	2	6
Little Femme Osage, 1¼ miles downstream	2	6	2	6
Airport offsite sampling points:				
Cold Water Creek, southwest corner of site	1	2	1	2
Cold Water Creek, after site pond discharge	1	4	1	200
Cold Water Creek, northwest corner of site	1	2	1	3
Drainage ditch, north of site [a]				

[a] Ditch dry, no sample collected

4. National Reactor Testing Station
January–June 1965[5]

Health and Safety Division
U.S. Atomic Energy Commission
Idaho Falls, Idaho

The National Reactor Testing Station (NRTS) is located in a very remote area, which permits controlled releases of radioactivity from the projects with minimum hazard to sizable population groups. The NRTS surveillance program is conducted by the AEC's Idaho Operations Office. The monitoring program consists of periodic sampling of ground and surface waters, milk, and air. The locations at which these samples are taken are shown in figure 6. The results of the analysis of these samples are shown in table 12. No wheat results were reported for this period.

Offsite water monitoring

Low-level liquid wastes resulting from operation of the various facilities at the NRTS are released to the ground-water table through disposal wells and ponds located near the facilities. Although liquid wastes are monitored at

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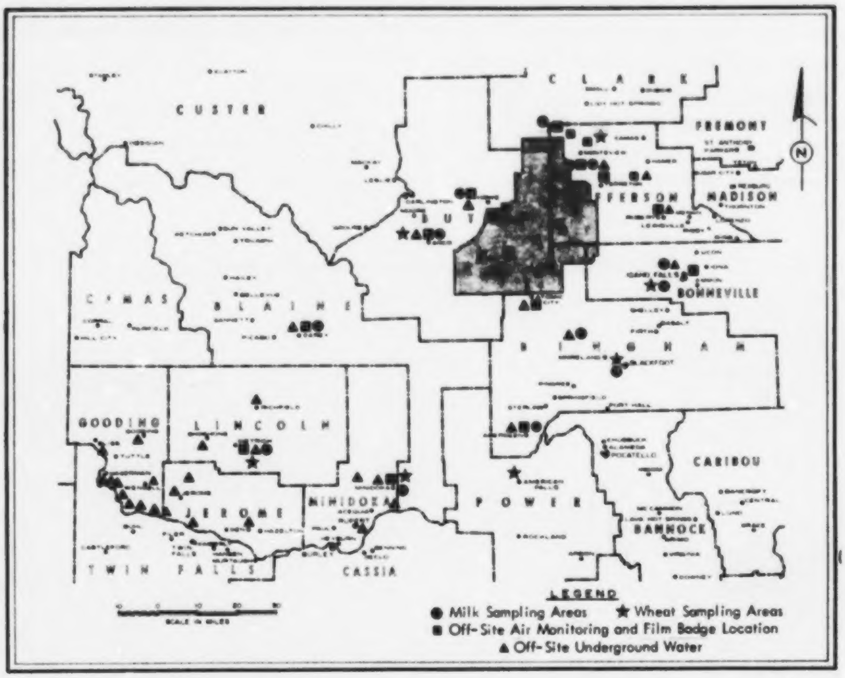
[5] Summarized from "Environmental Monitoring Report No. 16, First and Second Quarters 1965," U.S. Atomic Energy Commission, Idaho Operations Office, Health and Safety Division, National Reactor Testing Station.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BONNEVILLE
BINGHAM
GOODING
LINCOLN
JEROME
MINIDOKA
POWER
CARIBOU
BANNOCK
TWIN FALLS
CASSIA
N
SCALE IN MILES
LEGEND
● Milk Sampling Areas ★ Wheat Sampling Areas
■ Off-Site Air Monitoring and Film Badge Location
▲ Off-Site Underground Water

Figure 6. Environmental monitoring stations, National Reactor Testing Station

Table 12. Environmental monitoring data for the National Reactor Testing Station, January–June 1965

Type of sample and units	Number of stations	Approximate frequency of collection	Type of analysis	Minimum level of detection	Maximum activity of single sample	Average activity per sample	Applicable concentration guides
Offsite underground water (pCi/liter)	32	Semiannual	Alpha Beta	3 6	4 20	<4 9	100 100
Onsite production well water (pCi/liter)	22	Biweekly	Alpha Beta	3 6	4 100	<4 <10	3,000 3,000
Offsite air (pCi/m³)	ᵃ 15	Continuous	Beta-gamma Iodine-131	1.6 3.6	6 6	<2 <4	100 100
Offsite milk (pCi/liter)	12	Monthly	Iodine-131 Strontium-90	20 1.5	63 24	<20 13	100 200
Offsite area monitoring badges (mR)	ᵃ 15	Monthly	Gamma	10	<10	<10	170/yr

ᵃ Changed from 15 stations to 12 in April of 1965.

the NRTS before disposal, offsite underground samples are collected regularly. Most of these samples are taken from an area southwest of the NRTS since this is the prevalent direction of underground water flow. During the first half of 1965, 32 samples were collected on a semiannual basis from 32 sampling stations. The average concentrations of alpha and beta emitters were less than 4 percent and 9 percent of the applicable concentration guides. The alpha activity is attributed primarily to radioactive elements which are naturally present in the environment.

Onsite water monitoring

Onsite samples were taken from the plant production wells in order to monitor potable water for detection and definition of contamination. Two hundred and one samples were collected from 22 sampling stations during the

208

first half of 1965, most on a biweekly basis. Analyses of these samples showed that average concentrations of alpha and beta emitters were less than 0.2 percent and 0.4 percent of their respective concentration guides.

Offsite air monitoring

Normal operations of the present radio telemetry system calls for hourly reports by each station. These reports include information from:

Ion chamber: This instrument measures ambient radiation levels in mR/hr.

GM counter: HV–70 filter paper is cycled to a GM tube once a day. One GM tube measures the buildup of particulate activity over the day and another measures the decay of the activity collected the previous day.

Scintillation counter: Air which has previously passed through the HV–70 particulate filter then passes through a carbon cartridge. For surveillance purposes, the activity which is measured hourly is assumed to be iodine–131. This cartridge remains in place for periods up to 6 weeks.

Results of the data reported from the 15 radiation telemetry stations indicate that the sum of the average concentrations of gaseous iodine–131 and particulate activity in the atmosphere was less than 6 percent of the applicable concentration guide.

Offsite milk monitoring

Routine analyses of iodine–131 and strontium–90 concentrations in milk continued on a monthly basis during the first half of 1965. However, during the latter part of May, significant concentrations of iodine–131 were detected in the Idaho Falls area Grade A milk. An intensive milk sampling program was initiated during the period May 25 through June 20, 1965. The highest concentration measured during this period was 310 pCi/liter. This increase in radioactivity was attributed to fallout from the Chinese nuclear test on May 14.

Of the 72 routine analyses, only 8 samples were found to have concentrations greater than 20 pCi/liter. As indicated in table 12, the average iodine–131 levels, including the May-June samples, do not exceed 23 percent of the applicable concentration guide. Strontium–90 concentrations in the same 72 samples showed the maximum activity to be 24 pCi/liter or 12 percent of the applicable concentration guide with an average value of only 7 percent.

Offsite area monitoring badges

Offsite film badges were collected on a monthly basis during the first half of the year. The maximum radiation dose at a single location for any month as measured by film, was <10 mR of gamma radiation. The minimum detection limit for the 6 months was 60 mR of gamma, based on 6 film changes and a detection limit of 10 mR gamma on each film. For the purpose of calculating the maximum dose, each statistically zero result was assumed to be at the detection limit. The reported maximum is therefore conservatively estimated to be the upper limit of the true dose at that location. Natural background radiation levels at film badge locations vary, but studies made prior to nuclear operations at the NRTS showed that normal background levels were of the order of 100–150 mR/yr. This indicates that NRTS operations add no significant radiation to surrounding areas.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1960	*May 1961*
January–June 1961	*January 1962*
July–December 1961	*June 1962*
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Calendar year 1963	*September 1964*
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July–December 1964	*September 1965*

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January-June 1961	*January 1962*
July-December 1961	*June 1962*
Calendar year 1962	*June 1963*
Calendar year 1963	*September 1964*
January-June 1964	*March 1965*
July-December 1964	*September 1965*

Section V. Technical Notes

GROSS ALPHA RADIOACTIVITY OF HUMAN BONES AND TEETH

William E. Rothe[1]

Bone sections from 51 cadavers, and molar teeth from 75 patients were analyzed for total alpha activity during the period from June 1964 to May 1965. The observed levels are similar to those reported by R. C. Turner *et al.*, in 1958 (*1*). However, additional data from larger samples and different age groups may be of interest to investigators concerned with the naturally occurring alpha levels in man.

Methods

Rib sections were obtained from autopsy with no selection as to cause of death. Each bone was boiled in de-ionized water, scraped clean of tissue, dried, and ashed at 700°C. for 5 hours. Molar teeth extracted during routine dental procedures were cleaned of calculus and tissue, separated from any foreign material, and ashed at 900°C. Our sample preparation and analysis for total alpha activity followed closely the methods described by Oberhausen (*2*). In brief, the ashed tissues were finely ground and a 1-gram aliquot was mixed with 1 gram of silver-activated zinc sulfide and sealed in a plexiglass container. The container was then placed against a photomultiplier and the alpha-induced scintillations counted in the usual manner. This arrangement is very sensitive, and has a stable background of less than 2 counts per hour, with an average counting efficiency of 35 percent. All samples were counted for a period of 48 hours, or until a total of 1,000 counts had been recorded.

Results and discussion

Table 1 is a listing of the total alpha activity found in the ash of rib sections obtained from human cadavers. The subjects involved were American citizens residing in Western Europe. Sex and age do not seem to be a factor in the rather wide range of activities.

Three groups of people furnished teeth for analysis. The exposure history of these people is not available. The Landstuhl group were American citizens. Those from Bad Kreuznach and Karlsruhe were Germans who had lived in these cities for the past 5 years. The alpha activities found are listed in table 2. There does not appear to be a significant difference in the group levels of total alpha activity.

Table 1. Alpha levels in human ribs

Patient groups		Activity, pCi/g ash	
Age (years)	Number	Mean ± s.d.	Range
14-19	7	0.075 ±0.012	0.021-0.131
20-29	21	0.123 ±0.133	0.034-0.435
30-39	8	0.153 ±0.082	0.052-0.269
40-49	9	0.090 ±0.031	0.038-0.143
50-86	6	0.118 ±0.104	0.031-0.300

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Table 2. Alpha levels in human molar teeth

Source	Patient groups		Activity, pCi/g ash	
	Age (years)	Number	Mean ± s.d.	Range
Landstuhl........	18-29 30-39 40-48	25 6 6	0.213 ±0.142 0.238 ±0.109 0.211 ±0.132	0.096-0.669 0.121-0.376 0.077-0.365
Bad Kreuznach...	25-45	19	0.169 ±0.093	0.067-0.325
Karlsruhe........	25-45	19	0.216 ±0.117	0.033-0.584

It is not planned to continue monitoring adult teeth for alpha activity since the levels are usually unrelated to the current exposure history of the individual. However, additional work is underway with human bone in an effort to quantitate the concentrations of normally occurring alpha emitters.

REFERENCES

(*1*) TURNER, R. C., *et al.* The alpha-ray activity of human tissues. Brit J Radiol 31:397 (1958).

(*2*) OBERHAUSEN, E. Eine szintillationsanordnung zur messung sehr geringer alphastrahlaktivitaeten. Wissenschaftliche Fragen des Zivilen Bevoelkerungsschutzes 3:1 (1959).

REPORTED NUCLEAR DETONATIONS, FEBRUARY 1966

Two United States nuclear tests were announced by the Atomic Energy Commission during February 1966. Low yield tests (less than 20 kilotons) were conducted underground at the Commission's Nevada Test Site on February 3 and February 24.

The Commission also announced detection of seismic signals on February 13 from the Soviet nuclear testing area in the Semipalatinsk region. The signals were equivalent to those of a nuclear test in the low-intermediate (20–200 kiloton) to intermediate (200 kilotons to 1 megaton) yield range.

INVESTIGATIONS OF WEAPONS CARRIER ACCIDENT IN SPAIN

Following the January 17 collision of a B-52 carrying unarmed nuclear weapons with a KC-135 refueling plane, approximately 1,500 cubic yards of earth and vegetation were collected in southeastern Spain to preclude any possibility, however remote, of public health or safety hazard. There was no nuclear detonation.

The earth and vegetation contain only small quantities of radioactive material scattered when the nuclear weapons impacted. The material will be shipped to the AEC's Savannah River Plant, near Aiken, S.C., where it will be burried in the same manner as is used for disposal of other low-level radioactive waste material.

The material is being packed in 55-gallon drums. The levels of radioactivity are being carefully monitored to be sure they are well within the standard limits for such shipments.

SYNOPSES

VARIABILITY OF FLUID MILK CONSUMPTION AND ITS RELATIONSHIP TO RADIONUCLIDE INTAKE. *J. C. Thompson, Jr.* (Cornell University). *Radiological Health Data and Reports, Vol. 7, March 1966*, pp. 139 to 144.

Using Federal milk marketing order statistics and population estimates for market areas, average monthly fluid milk consumption estimates were derived for cities located in areas covered by the Public Health Service Pasteurized Milk Network. The average per capita milk consumption for 67 cities in July 1962 was found to be 0.302 liters per day, which compared well with the Bureau of the Census estimate of 0.297 liters per day for the same month. Establishment of a comparative milk consumption-radionuclide level network is described for the 38 cities which participate in both collection of the milk order statistics and the PHS milk monitoring system. This method is useful for determining regional and temporal variations in average milk consumption. Widespread geographic variations in radionuclide intakes are apparent from a summary of data for these cities, ranging to as high as sixfold for strontium-90 and fifteenfold for cesium-137 between stations. The estimates indicate that the average intake of strontium-90 and cesium-137 are approximately 70 percent less than estimates based on an assumed milk consumption of 1 liter per day. It is emphasized, however, that the averages include portions of the population whose milk intake is considerably greater than the average. These represent the critical elements in public health planning if large releases of radioactivity should occur.

KEY WORDS: cesium-137; consumption; intake; marketing orders; milk; population; radionuclides; strontium-90.

CESIUM-137 IN FOOD—A SUMMARY OF RESULTS ON SELECTED FOODS IN THE UNITED STATES, JULY 1962 TO OCTOBER 1963. *L. R. Setter, D. Smith, and M. Spector* (Division of Radiological Health, PHS). *Radiological Health Data and Reports, Vol. 7, March 1966*, pp. 145 to 156.

Cesium-137 content and cesium-137 to potassium ratios are summarized for nine staple foods sampled during a survey conducted for six consecutive quarters from July 1962 through October 1963. Insofar as possible, the results have been grouped by the six broad geographical production regions that were previously used for comparing strontium-90 data for the same samples.

The trend of the cesium-137 to potassium ratios was similar to the stontium-90 to calcium ratios previously reported, being generally higher in fruits and vegetables than in milk; however, the lowest ratios were found in lettuce, cabbages, potatoes, and eggs. It was noted that the region-to-region variations of cesium-137 concentrations were greater than those of strontium-90 for whole milk, evaporated milk, bread, apples, and oranges.

KEY WORDS: analyses; bread; cereals, cesium-137; cesium-137/potassium ratios; foods; fruit; meat; milk; potatoes; regional concentrations; survey; vegetables.